TMC 224

RAIL DEFECTS AND TESTING

Version 4.5

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Engineering Manual

Document control

Revision	Date of Approval	Summary of change
4.5	August, 2011	Changes detailed in Chapter Revisions
4.4	February, 2011	New C6-6 Testing of Rail Bond Welds; C-7, C6-8 and C6-9 renumbered; App 3 - Welding Return - only closures less than 6m in length need be crowed.
4.3	July 2010	C2-4.1 – New section dealing with management of defects in special track work; C4-4.2 – Additional treatment for squat laminations associated with wirefeed welds; C4-6 Changed detail in DWFW defect responses; Addition of requirements for retesting; C5-1 – Addition of note regarding shorting of track circuits; C6-1 – Addition of note regarding shorting of track circuits; C7-1 – Addition of note regarding shorting of track circuits; New C17-4 – Calibration of Bolt testing probe; C17-5 renumbered; Appendix 3 – Additional Welding Return Form WR2 to suit manual entry of data
4.2	December, 2009	Format change; Title changes to reflect organisation change; C4-2 - Added Straightness requirement; C4-2 Add restriction on aluminothermic welds sitting on track slabs
4.1	December, 2008	Chapter 1 - Additional reference; Added requirements in Section C2-1.2 for turning off lubricators prior to testing runs; Additional Testing requirements for Defective wire Feed Welds in Section C4-6 Internal Rail Defects; Added requirement to inspect monobloc crossings in Section C7-1; Additional Testing requirements for Defective wire Feed Welds in Section C10-13 Sizing Chart; Chapter 14 - Added Defect Size Coding; New Chapter17 – Ultrasonic Testing of Bolts. Includes content of CTN 08/07; New Chapter 18 – Visual Inspection of Monobloc crossings. Includes content of CTN 08/05; Added Defect Size coding to Form WAF 1
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3.0	October,2007	Addition of damage limits for foot damage, welds close to welds and joints and short closures
2.0	April, 2007	Inclusion of restriction on welder testing own welds; refinement of CME accountabilities for defect assessment and review; Minor corrections; revision of definition of TDX; inclusion of upgraded defect limits and responses for alignment defects; revision of defect limits for VSH defects. Revision of definition of HSH; Relaxation of restriction on welding near heat numbers in new rail; inclusion of method for measuring punch marks; Additional guidance on squat testing; testing of wirefeed in plain track; guidance on marking of testing; Extended area and type of testing; additional guidance on testing for crack predictors; removed requirement to dye test non-bearing part of switch; Additional guidance on gassing defects; addition of guidelines for setting up 0° probe for testing defect depth; Revision of defect limits for VSH defects; Revision to reflect changes of form
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Appendix 3	1.3	2	February, 2011	
Appendix 4	1.1	1	December, 2009	
Appendix 5	2.1	1	December, 2009	

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Chapter 1 Introduction

C1-1 Purpose

This manual provides requirements, processes and guidelines for the testing of rail for internal defects and for the acceptance testing of rail welds and weld repairs.

C1-2 Context

The manual is part of RailCorp's engineering standards and procedures publications. More specifically, it is part of the Civil Engineering suite that comprises standards, installation and maintenance manuals and specifications.

Manuals contain requirements, process and guidelines for the management of track assets and for carrying out examination, construction, installation and maintenance activities.

The manual is written for the persons undertaking rail testing activities.

It also contains management requirements for Civil Maintenance Engineers and Team Managers needing to know what they are required to do to manage rail testing activities on their area.

This manual is part of a series of seven (7) rail manuals

- TMC 221 - Rail Installation & Repair
- TMC 222 - Rail Welding
- TMC 223 - Rail Adjustment
- TMC 224 - Rail Defects & Testing
- TMC 225 - Rail Grinding
- TMC 226 - Rail Defects Handbook
- TMC 227 - Rail Management

C1-3 How to read the Manual

The best way to find information in the manual is to look at the Table of Contents starting on page 4. Ask yourself what job you are doing? The Table of Contents is written to reflect work activities.

When you read the information, you will not need to refer to RailCorp Engineering standards. Any requirements from standards have been included in the sections of the manual and shown like this:

The following requirements are extracted from RailCorp Standard ESC 220

On Curved Track

- Top surface requirements are as for straight track
- The horizontal alignment of the newly welded portion of rail must have a curvature consistent with the curvature of the existing rail, and the gauge face at the weld(s) must be smooth and continuous. . There must be no visible “elbow” at the weld.

Reference is however made to other Manuals.

C1-4 References

C1-4.1 Australian and International Standards

AS 2207 -1994: Non-destructive testing - Ultrasonic testing of fusion welded joints in carbon and low alloy steel

AS 2083-2005 Calibration blocks and their methods of use in ultrasonic testing

C1-4.2 RailCorp Documents

ESC 100 – Civil Technical Maintenance Plan

ESC 220 – Rail and Rail Joints

TMC 001 – Civil Technical Competencies and Engineering Authority

TMC 203 – Track Inspection Manual

TMC 221 – Rail Installation & Repair Manual

TMC 226 – Rail Defects Handbook

TMC 251 – Turnout Installation and Repair Manual

Chapter 2 Management Requirements

RailCorp has in place a Defect Management System for rail defects. The system includes periodic testing of rail for ultrasonic defects, recording of defects, limits and mandatory responses to the occurrence of defects and management of their removal.

Management requirements for the Defect Management System are detailed below.

C2-1 Rail flaw testing of plain track

C2-1.1 Manager Rail Inspection Services

Rail Flaw testing is a Safety Significant Inspection. The Manager Rail Inspection Services must:

1. Ensure that formal testing programs are established for on-track ultrasonic testing of rails to meet the requirements of RailCorp Standard ESC 100 - Technical Maintenance Plan.
2. Include in the testing program any additional testing required by the Civil Maintenance Engineers.
3. Manage the operation of the rail testing vehicles.
4. Provide resources to operate the car in accordance with the program.
5. Provide operating reports to maintenance areas including daily production details and defects detected.
6. Supply Civil Maintenance Engineers with details of locations where rail testing has been inhibited by gauge corner damage and associated lamination.
7. Monitor and report on the achievement of rail examination relative to the approved program.

C2-1.2 Civil Maintenance Engineer

Civil Maintenance Engineers must establish systems to ensure:

- Any additional routine testing requirements are advised to the Manager Rail Inspection Services. Guidelines for the establishment of rail testing intervals are provided in Chapter 15.
- Rail condition, including defect trends and conditions affecting testing is monitored, and appropriate protective or corrective action is taken.
- Locations of rail that are (or will become) overdue for testing are monitored each month.
- Appropriate corrective or protective action is taken if testing is overdue or if rail condition restricts testability.
- Appropriate protective action is taken if rail condition restricts testability. Where the track is unsignalled, determine additional safety measures. These may include additional track patrols or a further reduction in speed.
- Verification of defect sizing that is not able to be detected by manual ultrasonic examination, is undertaken.
- All kilometre posts are correctly located and visible to car crews during testing.
- Maintenance representatives are nominated and accompany the cars.
- Hard stand areas adjacent to the track, with all weather road access, are available at locations agreed with Rail Inspection Services for access by road/rail vehicles.
- Rail lubricators in areas to be tested are turned off in sufficient time so that grease on the rail head will not interfere with testing. The requirements are detailed in TMC 221. The lubricators should be turned back on as soon as practicable after the rail flaw inspection
- Appropriate action is taken to protect or remove rail defects when they are detected.
- Manual ultrasonic testing is conducted as required in accordance with Section C6-1 of this manual.
- All 53kg/m rails (full lengths or closures) proposed for re-use in main lines are ultrasonically tested and classified in accordance with Section C6-2 of this manual.

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C2-2 Rail flaw testing of new welds

Rail Flaw testing of welds or weld repairs (aluminothermic or wirefeed) CANNOT be undertaken by the person who installed the weld.

C2-2.1 Civil Maintenance Engineer

Civil Maintenance Engineers must establish systems to ensure:

- All aluminothermic welds are tested after installation in accordance with ESC 100 - Technical Maintenance Plan and Section C5-1 of this manual.
- All wirefeed rail repairs are tested after installation in accordance with ESC 100 - Technical Maintenance Plan and Section C6-1 of this manual
- Appropriate action is taken to protect or remove rail defects when they are detected.

C2-2.2 Project Managers

Project Managers must:

- Designate an authorized RailCorp employee to enter the details of both the welds carried out and the ultrasonic test and alignment results into the SmartWeld system.
- Ensure completion of these forms in full and that all information is entered in the SmartWeld database.

C2-3 Rail flaw testing of turnouts

C2-3.1 Civil Maintenance Engineer

Rail Flaw testing of turnouts is a Safety Significant Inspection. Civil Maintenance Engineers must establish systems to ensure:

1. Formal testing programs for ultrasonic and dye penetrant testing of rails in turnouts are established and managed to meet the requirements of ESC 100 - Technical Maintenance Plan.

   In sections where Integrated Track Patrol has been implemented, the ultrasonic testing of turnouts and special trackwork includes testing for crack predictors in heeled switches.
2. Special crossing types are identified and the correct rail flaw inspection regime is applied.
3. Rail condition, including defect trends and conditions affecting testing is monitored, and appropriate protective or corrective action is taken.
4. Turnouts and other special trackwork that are (or will become) overdue for testing are monitored each month.
5. Appropriate corrective or protective action is taken if testing is overdue or if rail condition restricts testability.
6. Provide all resources to undertake the testing.
7. Provide reports on turnouts tested and defects detected.

C2-3.2 Team Managers

The existence of crack predictors in the heel area of heeled switches is a significant issue in areas where Integrated Track Patrol is operating. Team Managers must:

1. Check with Rail Flaw Detection Operators and receive Weekly Defect Summary Reports for heeled switches with strong crack predictors nominated for Supplementary Patrol.

Teams3 entry
Enter Crack predictors into Teams3 as a heel defect with size of crack predictor entered in size field.
2. Arrange for scheduled retesting of crack predictors in accordance with ESC 100 – Civil Technical Maintenance Plan.

3. If advised of a heeled joint with a crack predictor, ensure track patrol staff specifically observe for signs of cracking or breaks during Walking Patrols and Mechanised Track Patrols.
4. If advised of a heeled joint with a strong crack predictor, initiate Supplementary Patrol for the particular location in accordance with the requirements of Engineering Manual TMC 203 – Track Inspection, until the switch or closure rail is replaced.

Teams3 entry
Enter locations and details of components, defects or conditions requiring Supplementary Patrol into Teams3. *In the Proposed Action drop down box select Supplementary Patrol. (In addition to the normal method of recording the defect)*

C2-4 Management of defect removal

This requirement applies to the management of all rail defects found in plain track, turnouts and welds regardless of the means of detection.

All rail and weld defects in welded and CWR track must be reported and rectified in accordance with this manual.

Team Manager

The Team Manager is to manage the Defect Management System for Rail Defects including:

1. Obtain details of all rail defects detected on the area within 24 hours of their detection. This will include advice by the maintenance representative on the Rail Flaw Detection vehicle of any defects found.
2. Arrange and manage corrective action
3. Maintain defect details in the Defect Management System for Rail Defects.

Civil Maintenance Engineer

1. Ensure that the Defect Management System for Rail Defects is satisfactorily managed by the Team Manager.
2. Monitor the level of rail defects, assess the impact on rail performance and take appropriate action.
3. If a defect cannot be repaired within the nominated time period in Section C4-6, undertake a risk assessment to establish appropriate management of the risk. The Risk Assessment methodology is explained in Chapter 16.
4. Review records and defects for trend identification at least annually. The outcomes must be considered in the development of district maintenance strategies and Asset Management Plans.

Manager, Rail Inspection Services

5. The Manager, Rail Inspection Services is to maintain details of rail defects found by the Rail Flaw Detection vehicle.

C2-4.1 Management of defects in special track work

When defects are found in special track work (i.e. locations other than plain rail) careful assessment is required in each case. Such locations include crossings, wing rails, checkrails, switches (including expansion switches) and heel blocks. The assessment should consider any support provided by existing chocks/ bolting; whether the section can be plated; the defect shape and position in the rail section and what happens if it fails.

The assessment should result in a determination as to whether response requirements can be relaxed or if any additional actions are required such as closer monitoring or further reduction in speed

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Civil Maintenance Engineers must:

1. Ensure that a Defect Management Plan is established for defects that cannot be removed within default timeframes.
2. Monitor the implementation and effectiveness of the Defect Management Plan.
3. Take appropriate action for the continuing integrity of the rail system.

C2-5 Recording and reporting rail defect detection and removal

This requirement applies to all rail defects found in plain track and welds regardless of the means of detection.

Submit a completed Rail Fail Form RF1 (See Appendix 1) for each rail or weld that fails in service on any running line whether main, loop, refuge, relief road, goods road or siding, no matter what the reason for failure. DO NOT include rail failures in Private Sidings.

Report all rail failures in switches, crossings, closures, stockrails, check rail carriers, junction rails as well as plain rails. In addition, report failures in check rails and guard rails even though they are not classed as running rails.

DO NOT complete a report for rails that are removed from track and renewed as part of a rerailing program.

Person finding defect

1. If the defect requires urgent attention, arrange appropriate correction or protection.
2. If Vertical Split Head defects are found in night inspections and cannot be visually examined to meet the requirements of Chapter 11 arrange for the defect to be inspected in daylight hours in accordance with the requirements of ESC 100 - Technical Maintenance Plan.
3. Complete a Rail Fail Form RF1 (See Appendix 1), using the guidelines in Chapter 13 for all rail defects as soon as practicable after the defect is found (within 24 hours).
4. Forward the form to the Team Manager.

Team Manager

1. Check each Rail Fail Form RF1 for completeness and accuracy.
2. Determine appropriate corrective action. The action required for each type of defect is detailed in Chapter 3.
3. Complete an instruction to carry out the corrective action using the guidelines in Chapter 13.
4. Forward a copy to the appropriate staff directing that the work be completed.
5. Monitor the progress of the repair of all defects, giving particular attention to defects overdue for removal.

Team Leader

1. Undertake the work to remove or repair the defect as instructed.
2. Endorse and return the copy of the Rail Fail Form RF1 to the Team Manager.

Team Manager

1. Complete the Rail Fail Form RF1 and forward a copy to the Civil Maintenance Engineer as soon as practicable.

Civil Maintenance Engineer

1. Retain a copy and forward a copy to Rail Inspection Services.

Manager, Rail Inspection Services

1. Provide consolidated details of rail defects.

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C2-6 Completing a Weld Alignment Failure form

As required in Section C5-4, all new field welds are tested for geometric alignment.

When a defect is detected:

The **Person finding the alignment defect** will:

1. Fill in a Weld Alignment Failure Form WAF1 (See Appendix 2) using the guidelines in Chapter 14.
2. Forward all copies to the Team Manager.

The **Team Manager** will:

1. Arrange for the area office to complete fields nominated in the Guidelines.
2. Write down remedial action required and who will perform it.
3. Forward a copy to the person who has been instructed to remove the weld alignment failure.
4. Forward a copy to the manager in charge of the welder if not under the Team Manager's control.

The **Person instructed to remove weld alignment failure** will:

1. Rectify the weld alignment failure.
2. Complete appropriate section of the form.
3. Return the copy to the Team Manager.

The **Team Manager** will:

1. Acknowledge removal of the defect.
2. Arrange for the defect to be retested if the defect has been corrected by grinding.
3. Forward the copy to the Rail Flaw Detection operator for completion if a retest is required.
4. Retain completed form for management of welders' performance.

C2-7 Monthly return of turnouts and welds

1. Ultrasonic Rail Flaw Detection operators are required to record:
   - ~ the detail of all turnouts tested and defects found, and
   - ~ summary detail of welds tested (both aluminothermic and wire feed welds)

   on the Turnout and Weld Testing Report Form MRTR1 (see Appendix 5).
2. At the end of each month return the form to Team Manager.

The Team Manager will:

1. Maintain copies of the report and forward it to Rail Inspection Services.

Technical Officer Rail Testing, Rail Inspection Services

1. Will review information supplied and prepare consolidated details of to the Chief Engineer Track.

C2-8 Management of broken rails

When broken rails are found they must be dealt with as follows:

Team Leader

1. Follow the requirements of to assess protect and remove the broken rail.
2. Follow the requirements of Chapter 12 to complete and forward a Rail Fail Form RF1 and pieces of the broken rail to Rail Inspection Services.

Technical Officer Rail Testing, Rail Inspection Services

1. Conduct a visual examination of each broken rail to determine the cause of the failure.
2. Compile a Broken Rail Report within 21 days of the break, detailing:
   - ~ Cause and growth of failure.
   - ~ Comments on whether the rail defect leading to the failure would have been of a detectable size during the last ultrasonic testing run. A response from Speno may be required to validate this.
   - ~ Photograph of the fracture face and shape of failure plane.
3. Send copies of the Broken Rail Report within 28 days of the break to
   - ~ The Civil Maintenance Engineer
   - ~ Chief Engineer Track

Chief Engineer Track

1. Arrange for further examination by a metallurgist where RIS are unable to determine the cause of the rail failure, or where there are other outstanding issues.
2. Give the manufacturer an opportunity for review where the rail failure is determined as a manufacturing defect.
3. Determine further actions if necessary.

C2-9 Recording of broken rails

The Chief Engineer Track maintains the Broken Rail Database. It contains all the fields included on the Broken Rail Form for all the broken rails on the RailCorp network.

When a completed Broken Rail Form is received from the field enter the information into the database.

When a completed Broken Rail Report is received from Rail Inspection Services enter the additional information into the database.

C2-10 Monthly & annual broken rail reports

Using the information contained in the Broken Rail Database monthly reports are produced by Track Services. These reports highlight trends in numbers of broken rails in different districts by comparison to previous years and months. A more detailed report is compiled and published annually.

Whilst ALL broken rails are entered in the Broken Rail Database only broken rails in main lines are included in the Broken Rail count and reported in monthly and Annual reports.

Chapter 3 Competencies

NOTE: These competencies may enable activities to be carried out in other manuals. For a comprehensive list of all activities that are covered by a given competency see Engineering Manual TMC 001 – Civil Technical Competencies and Engineering Authority.

To carry out this work	You need these competencies
Ultrasonic examination of field welds	TLIS3010A - Test rail using ultrasonic equipment NOTE: You CANNOT test welds that you have installed
Alignment Testing of welds	TLIS3010A - Test rail using ultrasonic equipment **OR** TLIW3015A - Weld rail using aluminothermic welding process **OR** TLIB3094A - Check and repair track geometry
Visual examination and adjustment check (punch mark check)	TLIS3010A - Test rail using ultrasonic equipment **OR** TLIW3015A - Weld rail using aluminothermic welding process **OR** **OR** TLIB3102A - Adjust rail **OR** TLIB3100A - Visually inspect track infrastructure
Ultrasonic examination of rail using hand held equipment	TLIS3010A - Test rail using ultrasonic equipment
Ultrasonic testing of turnouts and special trackwork using hand held equipment	TLIS3010A - Test rail using ultrasonic equipment **AND** TLIS3011A - Test rail using non-destructive testing equipment
Test switch tips using dye penetrant	TLIS3010A - Test rail using ultrasonic equipment **AND** TLIS3011A - Test rail using non-destructive testing equipment
Visual Assessment of Manganese & CV Crossings	TLIS3010A - Test rail using ultrasonic equipment **AND** TLIS3011A - Test rail using non-destructive testing equipment
Assess VSH Rail Defects	TLIS3010A - Test rail using ultrasonic equipment **AND** TLIS3011A - Test rail using non-destructive testing equipment **OR** Staff certified as competent in the use of the guidelines in C11-2 of this manual by the CME
Assess broken rails for continued traffic	TLIB3100A - Visually inspect track infrastructure **AND** TLIB3099A - Examine track infrastructure **AND** TLIB3094A - Check and repair track geometry

Chapter 4 Rail Condition Operating Limits and Responses

This chapter details the definitions for the classification of rail defects by size and type, together with remedial actions to be taken.

C4-1 Definitions

Broken Rail

A broken rail is defined as forming two separate pieces (ie clean break or piece broken out). It includes breaks in switches and welds. It does not include breakaways or broken plates.

Note: Small sections of rail eg head flow, shelling or foot damage are not included as broken rails.

Cracked Rail

A rail that has a crack or cracks visible in any part but no piece has been broken out.

Multiple Transverse Defects (TDX) occur as follows:

1. When 2 or more defects are closer than 2.2m apart.
2. Where a rail length between any two welds (flashbutt or aluminothermic) has more than one defect in a single run and where there are indications of below size defects at other locations in the rail length.

C4-2 Rail Geometry

The following requirements have been extracted from RailCorp standard ESC 220

- Mechanical joints shall be constructed with a gap of 6mm between rail ends at design neutral temperature of 35^0C.
- Joints shall be installed suspended between adjacent ties.
- Joints are not permitted in continuously welded track except within turnouts.
- Permanent mechanical joints are not permitted on bridges.
- Temporary mechanical joints on bridges are limited to no more than 7 days.

C4-3 Weld Alignment

The following installation requirements have been extracted from RailCorp standard ESC 220

Straightness

Welds shall be vertical to the top surface of the rail with no more than 5mm mismatch between the top and bottom of the weld

Alignment

The top surface and rail alignment is to be checked with a 1m straight edge as illustrated in Figure 1 and Figure 2 (top surface) and Figure 3 and Figure 4 (alignment). The permitted tolerances are as shown in Table 1.

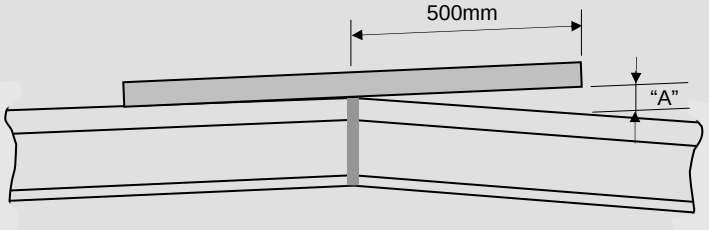

Figure 1 - Weld misalignment tolerance in vertical plane (peaking

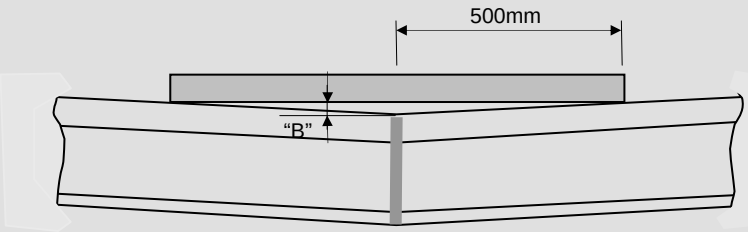

Figure 2 - Weld misalignment tolerance in vertical plane (hollow)

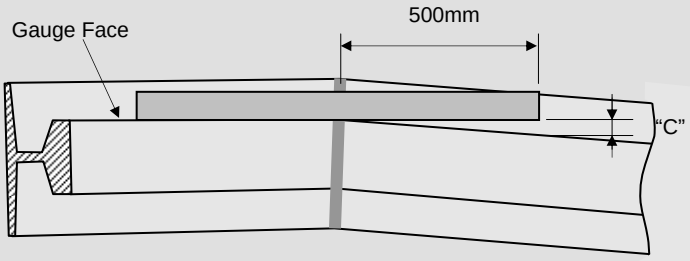

Figure 3 - Weld misalignment tolerance in horizontal plane (tightening)

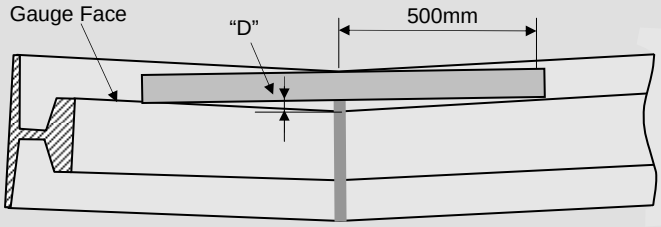

Figure 4 - Weld misalignment tolerance in horizontal plane (widening)

On Straight Track

Weld Surface/Alignment Limits	"A" mm	"B" mm	"C" mm	"D" mm	Vertical step mm	Horizontal step mm
For rail on concrete sleepers (new rail or rail in good condition)	0.6	0.3	0.6	0.3	± 0.3 over 100	± 0.3 over 100
Other situations	1.0	0.5	1.0	0.5	± 0.3 over 100	± 0.3 over 100

Table 1 - Weld Surface/Alignment Limits

On Curved Track

Top surface requirements are as for straight track.

The horizontal alignment of the newly welded portion of rail must have a curvature consistent with the curvature of the existing rail, and the gauge face at the weld(s) must be smooth and continuous. . There must be no visible "elbow" at the weld.

Remedial action detailed in Table 2 is required for all weld alignment defects, whether found by a Rail Flaw Detection officer or by other inspections.

Defect type	Defect size		Rectify within
	For new rail or rail in good condition on concrete sleepers	Other situations	
DIP WELDS (WTD)			
Small (WTDS)	Dip >0.3mm ≤ 0.6mm	Dip > 0.5mm ≤ 1.0mm	90 days.
Medium (WTDM)	Dip > 0.6mm ≤ 0.9mm	Dip > 1.0mm ≤ 1.5mm	30 days
Large (WRDL)	Dip > 0.9mm	Dip > 1.5mm	14 days.
PEAK WELDS (WTP)			
Small (WTPS)	Peak > 0.6mm ≤ 1.2mm	Peak > 1.0mm ≤ 2.0mm	90 days
Medium (WTPM)	Peak > 1.2mm ≤ 1.8mm	Peak > 2.0mm ≤ 3.0mm	30 days
Large (WTPL)	Peak > 1.8mm	Peak > 3.0mm	14 days
GAUGE NARROW (WTGN)			
Small (WTGNS)	Narrowing > 0.6mm ≤ 1.2mm	Narrowing > 1.0mm ≤ 2.0mm	90 days
Medium (WTGNM)	Narrowing > 1.2mm ≤ 1.8mm	Narrowing > 2.0mm ≤ 3.0mm	30 days
Large (WTGNL)	Narrowing > 1.8mm	Narrowing > 3.0mm	14 days
GAUGE WIDE (WTGW)			
Small (WTGWS)	Widening > 0.3mm ≤1mm	Widening > 0.5mm ≤1mm	90 days
Medium (WTGWN)	Widening > 0.6mm ≤ 0.9mm	Widening > 1mm ≤ 1.5mm	30 days
Large (WTGWL)	Widening > 0.9mm	Widening > 1.5mm	14 days

Table 2 – Remedial action for weld alignment defects

C4-4 Rail Surface Condition

C4-4.1 New welds

The following installation requirements have been extracted from RailCorp standard ESC 220

All welds shall be ground to the profile of the rail each side of the weld with no visible deviations from a straightedge.

The gauge face will normally be parent rail and shall be visibly smooth and consistent with the curvature of the existing rail.

C4-4.2 Squat defects

Squats should be recorded during normal patrol and other inspections and monitored for growth. They are to be reported as defects in Teams 3 using the guidelines in Table 3 below.

In areas where squats are present close attention should be given to the results from the ultrasonic test vehicle.

Size	Single Defect	Multiple Defects (less than 300mm between)
Small (< 30mm wide by 30mm long)	12mths – T3	3mths - T3
Medium (< 60mm wide by 80mm long)	3mths – T3	1mth – T2
Large (> 60mm wide by 80mm long)	1mth - T2	7days - T1

Table 3 - Squat Defect Classification and Removal Priority

Note 1. The priority should be increased if the squat defect is causing impact damage to the track.

Note 2: Arrange for testing by Rail Flaw Detection operators who can establish the depth and look for any other cracking that may be developing from the original squat.

Where evidence of squat laminations is found in the heat affected zone of wirefeed welds they must be dealt with in accordance with Table 4.

Defect	Plate within	Remove within	Other Action
Long squat laminations in the heat effected zone of wire feed repairs	7 days	5 months	Monitor for the early signs of any squats forming over wire feed repairs

Table 4 - Squat lamination action

Repair of Squat defects can be carried out by wire-feed welding (if they are small) or by aluminothermic head repair. If multiple medium or large defects exist it may be necessary to use a rail closure. Grinding out would not normally be an option unless the KK identified that the squats were very shallow (less than 1-2mm). Rail grinding is, however, important to stop very small squats from initiating and growing. Grinding should be carried out on a regular basis in areas where squats have been found to prevent new squats developing.

Further information can be obtained from RailCorp Engineering Manual TMC 226 - Rail Defects Handbook.

C4-5 Welds near other welds, rail ends, bolt holes and signal bonding holes

The following requirements have been extracted from RailCorp standard ESC 220

Distance between the welds and any boltholes

– 6 Hole Pattern - Rails which have all 3 holes bored on each rail end must be cut behind the first bolthole so that a minimum of 80mm is achieved from the weld to the first bolthole (see Figure 5).

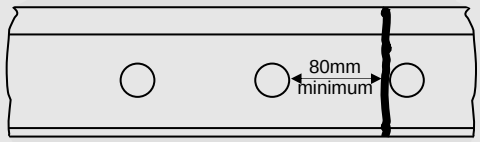

Figure 5 - Minimum distance of bolthole from weld

Welding near signal bonding holes

Aluminothermic welds may not be placed within 80mm of any holes drilled in the rail web for attachment of signalling bonds. This includes holes currently in use, those no longer in use and those that have been plugged.

Note: The end of the cut rail can not be located after the weld has been completed. When testing welds for compliance the measurement from the weld collar to the bolthole or bonding hole shall be 70mm.

Match of rail ends

The closure must conform to existing rail with a maximum 5mm mismatch in height (unless the rail is being welded using a junction weld in which case appropriate limits apply) and 5 mm in gauge wear.

Distance between the welds and other welds or joints

Rail ends or Aluminothermic welds may not be located closer than 1.2 m from the centre of a bonded insulated joint.

Aluminothermic welds may not be placed within 2.2 metres of any weld (flashbutt or aluminothermic) or mechanical joint (main line or siding) except as indicated below:

– In Turnouts Aluminothermic welds may be placed closer than 2.2 metres to a minimum distance of 1.2m to a flashbutt weld, aluminothermic weld or rail joint (mechanical or glued) provided that -
  - The flashbutt weld or joint has no internal defects
  - The rail length is well secured by two ties with the ties held by more than two rails such that they will not be able to skew if the rail breaks in two places.
  - The aluminothermic weld is ultrasonically tested within 6 hours of completion.

Closures

The minimum length of a closure to be welded into track is 2.2 metres except as indicated below

– In turnouts, closures shorter than 2.2 metres to a minimum length of 1.2m may be used, provided that -
  - The closure is well secured by two ties with the ties held by more than two rails such that they will not be able to skew if the rail breaks in two places.
  - The aluminothermic welds are ultrasonically tested within 6 hours of completion.

Location of welds

Aluminothermic welds may be installed opposite each other on adjacent rails as long as gauge side of each weld is ground prior to passage of trains.

Aluminothermic welds are not permitted on a sleeper.

Aluminothermic welds shall not sit directly on slab track.

Remedial action detailed in Table 5 is required for all defects found in the location of welds, whether found by a Rail Flaw Detection officer or by other inspections.

Defect			Remove within
New welds (ie not previously tested) < 80mm from bolthole			30 days
Closure in plain track < 2.2m or weld < 2.2m from another weld	on 3 or 4 good sleepers	S	Review in 12 months
	on 2 good sleepers	M	6 months
	on 1 good sleeper	L	14 days
Weld in turnouts 1.2 to 2.2m from weld (flashbutt or aluminothermic) or mechanical joint	on 1 tie	L	14 days
Welds < 1.2m from the centre of a bonded insulated joint	on 1 tie with Joint in good condition	M	6 months
	on 1 tie with Joint in poor condition	L	14 days

Table 5 – Remedial Actions for weld proximity defects

C4-6 Internal Rail Defects

Internal Rail Defects - Limits and Responses

	Defect Type	Size definition Probe Movement (mm) (See Notes)		TSR (km/h)	Plate Within (See Notes)	Remove Within	Other Action
1	**Transverse Defect (TD)** Head - 70° Probe	S	40 to56		7 days	5 months	
		M	57 to 90		24 hours	5 weeks	
		L	over 90	30	2 hours	48 hours	Inspect clamp/ bolts after 24hrs of installation
2	**Multiple Transverse Defects (TDX)** Head - 70° Probe	S	40 to56	40	*See Notes*	7 days	Remove all defects from weld to weld. Individual defects can be removed provided the welds are situated clear of any below size defects and provided that the whole rail length is removed within 3 months.
		M	57 to 90	20		24 hours	
		L	over 90	10		ASP	Remove all defects from weld to weld. Monitor and stop trains if necessary until defect is removed
3	**TD in Shatter Cracked Rail (SC)** Head - 70° Probe			Same as TD. If multiple – same as TDX		If TD is reported in shatter cracked rail, the full length must be replaced weld to weld	
4	**Transverse Defect at Engine Burn - TD/EBF)** Head - 70° Probe	Same as TD				If complete reading not possible teat as TDM. Where several EBF exist in the same rail length consider replacing rail.	
5	**Defective Wire Feed Weld - (DWFW)** Head - 70° and Twin 70° Probe	S	25 to 56	As for TD		If defect contains another component of medium or greater size (e.g. HSW) increase the response by one band	
		M	57 to 70				
		L	over 70				
	Conduct 0° Probe test for laminations in wire feed welds. Use probe movements as for 70° Probe for defect assessment and classification.						
6	**Bolthole Cracked (BH)** Web - 38° probe	S	20 to 40			7 days	
		M	41 to 75	20		48 hours	
		L	over 75	10		ASP	Monitor defect and stop trains if necessary until defect removed
7	**Defective Welds - (DW)** Head - 70° and 0° Probe		Same as **TD**				Large defect, keep defective weld under observation until removed.
8	**Defective Welds Gassing defects (DW Gassing)** Full weld - 0° Probe	M	Loss of weld base signal over 35mm or width of weld		24 hrs	5 weeks	
9	**Defective Welds All horizontal web defects HSW, HWS, FWS**	M	15 to 75	30		48 hours	
		L	75 to 150	20		ASP	Monitor defect (min 6hrly) and stop trains if necessary until defect removed
		E	over 150	10		ASP	
10	**Defective Welds - (DW)** Web/Centre foot 38° probe	S	25 to 50		30 days	12 months	Keep under observation until removed.
		M	51 to 75		24 hrs	5 weeks	
		L	over 75	30	2 hrs	48 hours	Keep under observation until removed. (60km/hr once clamped but no greater than line speed) Inspect clamp/ bolts after 24hrs of installation
	When testing new Flashbutt welds remove all non-standard foot centre indications						
11	**Defective Welds - (DW)** Foot Twin 70° Probe	M	15 to 35 from *or* 10 to 35 if indication starts from outer edge of foot		24 hrs	5 weeks	Keep under observation until removed. Foot defect with 38°-probe treat as DW-M.
	Foot test for aluminothermic welds ONLY	L	over 35		2 hrs	48 hours	Keep under observation until removed.

Internal Rail Defects - Limits and Responses							
	Defect Type	**Size definition** **Probe Movement** (mm) (See Notes)		**TSR** (km/h)	**Plate Within** (See Notes)	**Remove Within**	**Other Action**
12	**Vertical Split Head (VSH)** 0° & Twin 70° Probe (See additional requirements in Notes at the bottom of this table)	I B	<50 long <15 from top **OR** >50 long >15 from top	*If distance between adjacent VSH is < 100mm treat as one defect. If > 100mm then treat as separate defects.*		Monitor	Routine ultrasonic testing (See Notes below)
		S	50-200 long <15 from top			5 weeks	Reclassify to medium if located within 1m of an aluminothermic weld
		M	201-400 long <15 from top			7days	
		L	>400 long <15 from top	40		5days	Monitor and stop trains if necessary until defect is removed. OR Assess (See Chapter 11).
		E	visible	10		ASP	Monitor and stop trains if necessary until defect is removed. OR Assess (See Chapter 11).
13	**Vertical Split Web (VSW)** 0° Probe	S	Any registration in rail length			6 months	Replace full rail length weld to weld
14	**Transverse Split web (TSW)** 0° Probe	S	20 to 40			7 days	
		M	41 to 75	20		48 hours	
		L	over 75	10		ASP	Monitor defect and stop trains if necessary until defect removed
15	**Piped Rail (PR)**	S	25 to 150			5 weeks	
		M	151 to 300			7 days	
		L	over 300	10		ASP	Monitor defect and stop trains if necessary until defect removed
16	**Horizontal Split Web (HSW)** 38° & 0° Probe	S	20 to 40			7 days	
		M	41 to 75	30		48 hours	
		L	75 to 150	20		ASP	Monitor defect (min 6hrly) and stop trains if necessary until defect removed
		E	over 150	10		ASP	
17	**Horizontal Split Head (HSH)** 38° & 0° Probe	S	25 to 100			5 weeks	
		M	101 to 200			7 days	
	Applies to horizontal indications with a depth of 10mm or more.						Monitor defect (min 6hrly) and stop trains if necessary until defect removed
18	**Head and Web Separated (HWS)** 38° & 0° Probe	S	20 to 75			7 days	
		M	76 to 200	20		48 hours	
		L	over 200	10		ASP	Monitor defect and stop trains if necessary until defect removed
19	**Foot and Web Separated (FWS)** 38° & 0° Probe	S	20 to 40			7 days	
		M	41 to 75	30		48 hours	
		L	76 to 150	20		ASP	Monitor defect (min 6hrly) and stop trains if necessary until defect removed
		E	over 150	10		ASP	Monitor defect (min 6hrly) and stop trains if necessary until defect removed
20	**Corroded Rail (CR)**	If reported by rail flaw detection car or manual ultrasonic test, maintenance staff to inspect in accordance with TMC 203.					
21	**Mechanical Joint Suspect (MJS)**	Remove plates and inspect within 14 days. If defect found refer to Bolthole defect.					
22	**Broken rail – (BR)**	Assess Broken Rail (See Chapter 12). Stop trains if necessary and replace broken rail ASP					

Internal Rail Defects - Limits and Responses

	Defect Type	Size definition Probe Movement (mm) (See Notes)		TSR (km/h)	Plate Within (See Notes)	Remove Within	Other Action
23	**Foot Damage – (FD)** Twin 70° Probe **OR**	M	≥10mm wide but < 35mm [sideways]		24 hrs	5 weeks	If other minor impact points are 5m or more away these can be left in track but checked regularly by the existing track patrol regime. Any rail with visible cracking should be monitored on a weekly basis by the Rail Testing Operator until the defect is removed to ensure that failure of the rail has not occurred.
	Visible cracking (often seen as a rust band)		< 35mm.				
	Twin 70° Probe **OR** Visible crack **OR**	L	≥ 35mm.		2 hrs	2 weeks	The length of rail affected by any additional impact damage or cracking should be removed with the defect/s.
	≥ 2 visible cracks or ultrasonic indications in a 2.5m length of rail.)		≥10mm wide but < 35mm		Note: If the appearance of a visible crack is not clear a magnifying lens and/or dye penetrant should be used to confirm the presence of a crack.		
	Foot indented **OR** edge of the foot has been bent or distorted	S	≤ 2mm		30 days *	12 months*	* alternatively, small defects may be able to be ground out if only the top of the foot is affected. Remove any remaining sharps by grinding
		M	> 2 ≤ 4mm		24 hrs	5 weeks	
		L	> 4mm		2 hrs	48 hours	

Notes:

Defect Size (Head Transverse)			Plated defects	Inclusion Bands (IB)	VSH Defects
Category		**% of head**			
S	Small	3 – 10%	Clamp plated defects with G Clamps for maximum 24 hrs or Robel clamps for maximum 5 weeks after which they must be bolted or removed.	Criteria to be met for IB:- 1. Indications are continuous 2. No visible cracking or discoloration. 3. Must not come within 100mm of Weld, Joint, BH and must be No significant dip in rail. 4. Rail tangent measured wear is not less than 10mm 5. VSH has not been detected in weld area.	Classify defect as next size up if : 1. visible discoloration 2. cracked out under head 3. runs into weld, BH, joint, other defect 4. tangent wear more than 10mm.
M	Medium	11 – 30%			
L	Large	>30%	If a clamped/plated defect is not removed within the time specified apply the default speed restriction		
E	Emergency				
Percentage figures are in relation to rail head area only.			Normally TDX aren't plated. Where there are sufficiently separated, they may be plated. If plated, the speed restriction applied may be reduced one level (eg TDX-M with a 20kph TSR may be lifted to 40kph)		Use Assessment Guidelines (See Chapter 11) if there is : 1. visible cracking 2. rail head collapse, 3. dip greater than 0.5mm 4. defect is over 1m long.
TDX are classified as size of largest individual defect					

Defects in special trackwork

When defects are found in special trackwork (ie locations other than plain rail) careful assessment is required in each case. Such locations would include; crossings, wingrails, checkrails, switches (including expansion switches) and heelblocks. The assessment should consider any support provided by existing chocks/ bolting; whether the section can be plated; the defect shape and position in the rail section and what happens if it fails. The assessment should result in a determination as to whether response requirements can be relaxed or if any additional actions are required such as closer monitoring, further reduction in speed

Retesting

All identified defects remaining in track longer than two months MUST be retested

Table 6 - Rail Defect Limits and Responses

Chapter 5 Aluminothermic Weld Testing

C5-1 Testing requirements

When you receive a Welding Return Form WR1 arrange to test the welds as follows.

DO NOT test welds ultrasonically or for alignment until at least two (2) hours after the finish grinding has been completed. The weld should be cool enough to touch by hand. This means in practice that a momentary touch of the weld should be as tolerable as a momentary touch on the rail on a hot day.

Important
Ultrasonic testing operators need to be careful when testing near insulated joints to ensure that no aspect of the testing procedure causes an electrical connection across the joint.

When you have completed the testing, return the completed form to the Team Manager.

C5-2 Ultrasonic testing

1. Test welds ultrasonically. The testing is separated into the following individual tests:

Head
Use a 70° probe to examine the rail head area of the weld. This probe is used to locate lack of fusion or inclusions in the head area. Use the testing procedure detailed in Section C8-2 to conduct the test.
Web
Use a 38° probe to examine the web area of the weld and that part of the flange (foot) directly beneath the web. This probe is used to locate lack of fusion or inclusions in these areas. Use the testing procedure detailed in Section C8-5 to conduct the test.
Foot (Flange)
Use a miniature twin 70° probe to examine the rail flange (foot) area of the field weld for lack of fusion and inclusions. Use the testing procedure detailed in Section C8-2.6 to conduct the test.
Full Rail/Weld
Use a 0° probe to examine the full height of the weld for Gassing (test for complete loss of back wall echo through the weld) [Junction welds excluded] and horizontal cracks. . Use the testing procedure detailed in Section C8-2.6 to conduct the test.

2. Establish the size of defects using the sizing procedures in Chapter 10 and by reference to the defect limits in Section C4-6.
3. Take appropriate action if defects require urgent attention.
4. When the weld has been ultrasonically tested, paint over it with blue paint if satisfactory and yellow paint if a defect is found. Make sure any pre-existing pink paint is painted out.

   Each new aluminothermic weld should have been marked in pink fluorescent paint by the welder after the weld has been completed.
5. Complete a Rail Fail Form RF1 (see Appendix 1) using guidelines in Chapter 13 for each defective weld.
6. Record the test result on the Welding Return Form WR1. (see Section C5-6)

C5-3 Visual examination

1. Measure the distance of the weld to other welds, rail ends bolt holes and signal bond holes.
2. Check whether the weld meets the distance requirements in Section C4-5.

3. Establish the size of defects by reference to the defect limits in Section C4-5.
4. Take appropriate action if defects require urgent attention.
5. Check that the weld has been ground to correct profile and that excessive grinding has not been undertaken.
6. Check the weld for discoloration (blueing). This is generally caused by grinding the weld while it is still hot. It is not correct practice and must be noted in the "Comments" field in SmartWeld for follow up.

Figure 6 – Blueing of rail

7. Check that rail closures (if 53kg rail) have a BLUE paint stripe. If no paint stripe exists, arrange ultrasonic testing of the closure in accordance with Section C6-8.
8. Mark each tested weld with paint the same as for ultrasonic testing.
9. Complete a Rail Fail Form RF1 (see Appendix 1) using the guidelines in Chapter 13 for each defective weld.
10. Record the test result on the Welding Return Form WR1 (see Section C5-6).

C5-4 Alignment testing

Note: Also use this method of test for alignment testing of flashbutt welds.

1. Test welds for top surface and rail alignment with a calibrated 1m straight edge and a taper gauge as illustrated in Figure 7 and Figure 8 (top surface) and Figure 9 and Figure 10 (alignment).

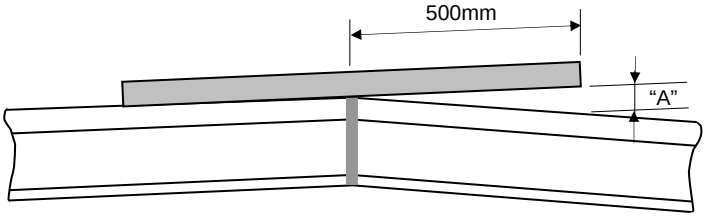

Figure 7 - Weld misalignment tolerance in vertical plane (peaking)

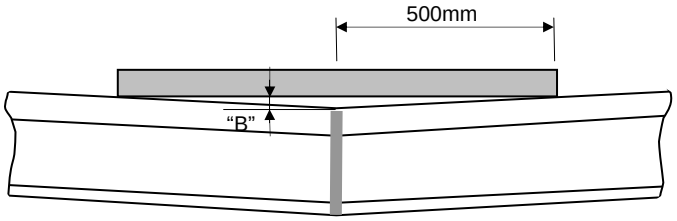

Figure 8 - Weld misalignment tolerance in vertical plane (hollow)

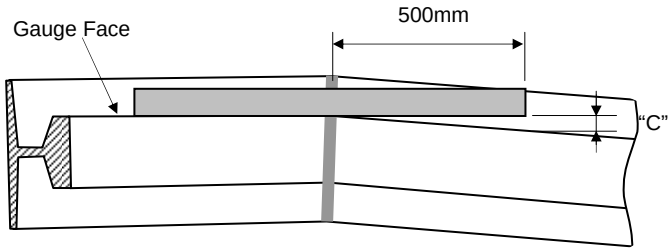

Figure 9 - Weld misalignment tolerance in horizontal plane (tightening)

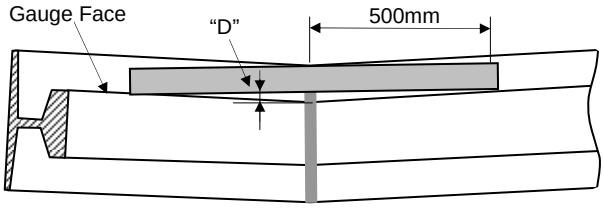

Figure 10 - Weld misalignment tolerance in horizontal plane (widening)

2. When testing for weld peaking:

   ~ Check alignment with the centre of the straight edge over the centre of the weld.

   ~ Move the straight edge so that one end is at the centre of weld and check alignment again.

   ~ Move the straight edge so that the other end is at the centre of weld and check alignment again.

   This additional check is essential to check that grinding of the weld has not transferred the peak error away from the centre of the weld.

   There are two different types of peak that do not comply with the defect limits.

   i. An excessive peak resulting from the rails being peaked too much, prior to welding. Attempts to remove this type of problem with a long grind do not result in the removal of the peak but in a transfer of the peak to another location away from the weld (See Figure 11). Classify this as a peak even though the peak is not in the weld. This can only be repaired with a closure.

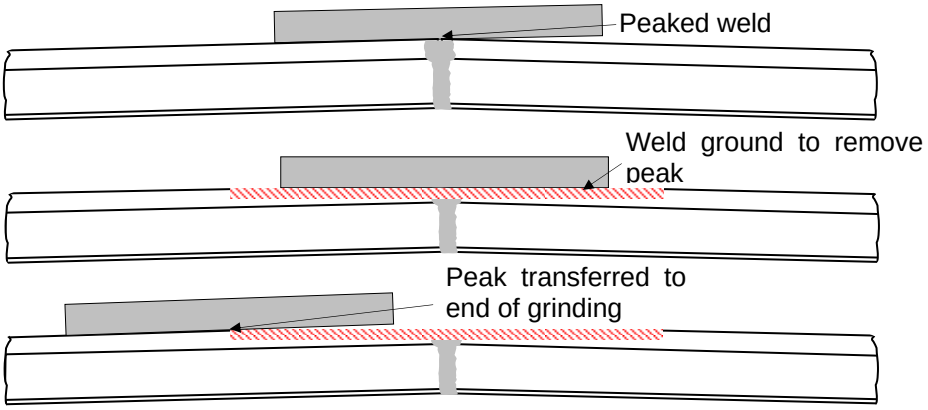

Figure 11 – Transfer of peaked weld by grinding

   ii. A peak resulting from insufficient removal of the weld metal. It can sometimes be the case that the weld is ground to profile on the gauge side but is left proud on the field side top of the rail head. This non-compliance will not correct itself no matter how long the weld is left in the track and means that the weld cannot be tested on the field side top and will be failed as a peak weld. This kind of peak is easily removed with further grinding.

   There are four different types of dip that do not comply with the defect limits.

   i. A dip resulting from the rails not being peaked enough prior to welding. This can only be repaired by a replacement weld or a rail bending process.

   ii. A dip resulting from the rails not being peaked enough prior to welding but the weld metal

has been left high to try and compensate. This is the most harmful alignment problem as the wheels hit this very hard. This also can only be repaired by a replacement weld or a rail bending process combined with grinding.

iii. A dip resulting from a dip in the track. Packing may resolve this problem but a 'memory' is often set up in the weld that can only be repaired with a closure or rail bending.

iv. A dip resulting from an attempt to weld a crippled rail joint. This can only be reliably repaired with a closure.

Dips cannot be removed with a long grind. This will only transfer the misalignment to another location away from the weld. Classify this as a dip even though it is displaced from the weld. This can only be repaired with a closure.

3. Establish the size of defects by reference to the defect limits and remedial action in Section C4-3.
4. Mark each tested weld with a paint dot on the web on both sides of the weld area approx. 100mm from the weld
   - ~ Blue Dots - if the alignment is satisfactory.
   - ~ Yellow Dots - if the alignment is not satisfactory.
5. Mark the date of examination and identification code of the operator on the rail.
6. Complete a Weld Alignment Failure Form WAF1 using giudelines in Chapter 14 for each weld that does not meet alignment limits in Section C4-2 even if it is removed before trains run over the weld.
7. Forward the form to the Team Manager
8. Record the test result on the Welding Return Form WR1.
9. If the alignment defects have been repaired by grinding, the Weld Alignment Failure form will be returned to you. Test the geometry again, following Steps (0) to (5) above.
10. Record the retest result on Weld Alignment Failure and on the Welding Return Form WR1 (see Section C5-6)
11. Return the completed forms to the Team Manager.

C5-5 Measuring punch marks

Where field welds have been installed in CWR track using the "rail out – rail in" process, measure and record the length between punch marks using the following method

1. Locate the punch marks. They should be on the outside head of the rail near the top of the face about 300mm either side of the closure and be marked with a white paint circle.
2. Place one end of a non-conductive measuring tape on the top of the rail head as close to one of the punch marks as possible.
3. Stretch the tape along the rail head to the second punch mark keeping it as straight and flat as possible.
4. Measure the distance between the 2 marks to the nearest mm and record the measurement on the Weld Return Form WR1 (see Section C5-6).

C5-6 Completing a Welding Return

Record the following information about each weld in SmartWeld (or on the Welding Return Form WR1 or WR2 if the SmartWeld system is not available (See Appendix 3). The fields on the form are explained in Table 7.

Non RailCorp Contract Welders or Rail Flaw testing personnel must use Welding Returns, RailFail forms and Weld Alignment Failure forms. Contract staff are not permitted to use SmartWeld.

Weld Testing Data	
Test Date	Enter date of test
Ultrasonic Pass	Circle YES or NO
Alignment Pass	Circle YES or NO
Punch Mark Check	Insert length between punch marks to three decimal places. If no punch marks write NIL
Rail Fail ID	Number of rail fail form completed for this weld defect Defect position and size information is contained on the Railfail form
Alignment Failure ID	Number of Weld Alignment Failure form completed for this weld defect Defect type and size information is contained on the Weld Alignment Failure form
RFD Operator's Name	Name of RFD Operator.
Signature	*(Not required in SmartWeld)*
Retest (Alignment only)	
Test Date	Date the weld is retested
Alignment Pass	Circle YES or NO
Alignment Failure ID	Complete a new Weld Alignment Failure form for a failed retest
RFD Operator's Name	Name of RFD Operator.
Signature	*(Not required in SmartWeld)*
Comments	Write down any comments relevant to the work

Table 7 - Information to be recorded on Welding Return

Chapter 6 Manual Ultrasonic testing

C6-1 Testing requirements for general rail testing

1. Test rail for defects. The testing is separated into three individual tests as follows:-

Head
Use a 70° probe to examine the rail head area for defects of a transverse nature only. Use the testing procedure detailed in Section C8-2 to conduct the test.
Web and flange
Use a 38° probe to examine the rail web and that part of the flange (foot) directly beneath the web. for defects of a transverse nature, including bolthole fatigue and weld defects. Use the testing procedure detailed in Section C8-5 to conduct the test.
Head, Web and flange
Use a 0° Probe to examine the rail head, web and flange for defects of a vertical or horizontal nature, including bolthole fatigue and longitudinal defects. Use the testing procedure detailed in Section C8-2.6 to conduct the test.

Important
Ultrasonic testing operators need to be careful when testing near insulated joints to ensure that no aspect of the testing procedure causes an electrical connection across the joint.

2. Establish the size of defects using the sizing procedures in Chapter 10 and by reference to the defect limits in Section C4-6.
3. Take appropriate action if defects require urgent attention.
4. Complete a Rail Failure Form RF1 (see Appendix 1) using the guidelines in Chapter 13 for each rail defect.

C6-2 Re-testing of rail defects

When retesting plated rail defects the following additional procedure applies

1. Check that the plates are installed with at least four (4) bolts. If not then mark the defect as a defect for the attention of the Civil Maintenance Engineer

C6-3 Additional testing of VSH defects

1. When a VSH defect has been detected, ultrasonically test the full rail length between flash butt welds. This is done from the outside (field side) of the rail head using a 0° probe using the procedure outlined in Section C8-7.
2. Arrange or undertake a visual assessment of the VSH defect (see Section C6-3.1).
3. Establish the size of defects using the sizing procedures in Chapter 10 and by reference to the defect limits in Section C4-6.
4. Take appropriate action if defects require urgent attention
5. Complete a Rail Failure Form RF1 (see Appendix 1) using the guidelines in Chapter 13 for each rail defect.

C6-3.1 Visual assessment of VSH defects

Additional inspection requirements for VSH examination are detailed as follows:

1. Measure the dip in the rail at the VSH defect using a 1 metre straight edge and a tapered feeler gauge.

2. Check at least 500mm either side of the marked defect for the initial inspection. In any subsequent inspection reduce this distance to 200mm each side.
3. Visually inspect the area for cracking or discoloration (rust band) especially on the root radius area where the web adjoins the underside of the head. Note especially the proximity to welds, boltholes and joint gaps. Inspect both sides of the rail.
4. Measure the tangent wear of the rail if significant tangent wear is obvious.
5. Check the area at the top of the web where VSH indications have been found in the rail head. This is to check if any cracks from the head have progressed into the web below the fillet area (the fillet area itself cannot be examined with current probes).

C6-4 Additional testing of squat defects

When a squat defect has been identified the following additional procedure applies:

1. Measure the depth of the cracks using an ultrasonic depth gauge.
2. Use a 0° probe placed on the head of the rail to determine the length of the crack horizontally using the sizing procedure in Chapter 10.
3. Effective testing within the laminated area using the 70° probe on top of the rail is unlikely to be successful. A test for large/medium transverse indicators under squat laminations can be conducted by testing with a 70° probe in both longitudinal testing directions along the gauge side vertical face of the head. The probe must be kept parallel with the edge of the rail with the probe sitting as flat as possible on the vertical surface. Transverse defects will however not always be located using this test.

C6-5 Testing of wire feed welds

C6-5.1 Testing before welding in plain track

When testing proposed wire feed weld repair areas in **plain track** the following additional procedure applies:

1. Test the proposed repair area (and 300mm each side) with a 0° probe (SEB2-OE) using the testing procedure in Section C8-2.6, paying particular attention to near surface cracks.
2. Record the location depth and length of all defect indications and report this information to the Team Manager.
3. Test with a 70° probe if no laminations are found with the 0° probe.
4. Test boltholes in the heat affected zone with a 38° probe.

C6-5.2 Testing before welding in crossings

When testing proposed wire feed weld repair areas in **crossings** the following additional procedure applies:

1. Test the proposed repair area. Check for:
   - ~ Defect indications that are too deep to be removed (more than 12mm deep from top of rail surface).
   - ~ Any bolthole defects in the preheat area. These crossings cannot be welded.
2. Mark defect indications (ignoring surface indications)
   - ~ Mark the extremities of horizontal indications and their length and depth.
   - ~ Mark the rail, locating the position of any transverse indications and their depth.
   - ~ Identify any ultrasonic indications below sizing code, (defect criteria) ie indications below a probe movement of 20mm.
3. Record all the above defect details and report these to the Team Manager.

C6-5.3 Testing new wire feed welds

When you receive a Welding Return Form WR1 arrange to test the welds as follows.

DO NOT test welds until at least two (2) hours after the finish grinding has been completed. The weld should be cool enough to touch by hand. This means in practice that a momentary touch of the weld should be as tolerable as a momentary touch on the rail on a hot day.

When you have completed the testing, return the completed form to the Team Manager.

C6-5.3.1 Ultrasonic testing of wire feed weld repairs in plain track

1. Test new wire feed welds ultrasonically for defects. The testing is separated into two individual tests as follows:

Head - 0° Probe
Use a 0° probe (currently a Krautkramer SEB2-OE) to find the longitudinal extremities of any laminations resulting from the wire feed repair. Use the zero probe to find the width of any lamination.
Head - 70° Probe
Conduct all testing of wire feed repairs with a 70° probe using three passes in each of the two testing directions for any transverse cracking resulting from the wire feed weld. DO NOT use a 70° probe to test over the lamination as spurious indicators will be obtained. Use the 70° probe to test before the lamination (Not closer than 40mmm) and immediately after the lamination for TD type indicators. If the lamination does not extend across the full width of the rail head then use the 70° probe to test the rail head adjacent to the lamination for any transverse indicators.

2. Test the repair area plus 100mm each side, paying particular attention to weld depth area (i.e. weld/rail interface).

   For wheel burn repairs, the start and finish of the repair should have been marked on the head and web of the rail by the welder at time of installation.
3. Establish the size of defects using the sizing procedures in C9-1 and by reference to the defect limits in Section C4-6.
4. Take appropriate action if defects require urgent attention.
5. Complete a Rail Failure Form RF1 (see Appendix 1) using the guidelines in Chapter 13 for each rail defect.
6. When the weld has been ultrasonically tested paint over the pink paint mark with blue paint if satisfactory and yellow paint if a defect is found.

   Each new wire feed weld should have been marked in pink flourescent paint by the welder after the weld has been completed.

C6-5.3.2 Ultrasonic testing of wire feed weld repairs in crossings and wing rails

1. Test new wire feed welds ultrasonically for defects. The testing is separated into the following tests.

Head - 70° Probe
Use a 70° probe to examine for transverse defects in the head that were not removed prior to welding, and transverse indications due to lack of fusion in the wire feed weld. Use the testing procedure detailed in Section C8-2 to conduct the test. When TD type defects are ultrasonically assessed prior to a repair weld, indicate the approximate depth in mm to assess viability of using a repair weld. NOTE - the heat of welding can cause a defect to increase in depth

Head - 0° Probe
Use a 0° probe (currently a Krautkramer SEB2-OE) to examine the rail head for horizontal laminations that were not removed prior to welding and horizontal laminations due to lack of fusion in the wire feed weld. Use the testing procedure detailed in Section C8-5 to conduct the test.
Web - 38° Probe
Use a 38° probe (currently a Krautkramer WB35 2E) to examine any boltholes for cracks. Use the testing procedure detailed in Section C8-3 to conduct the test.

2. Test the repair area plus 100mm each side, paying particular attention to weld depth area (i.e. weld/rail interface).
3. Establish the size of defects using the sizing procedures in C9-1 and by reference to the defect limits in Section C4-6.
4. Take appropriate action if defects require urgent attention.
5. Complete a Rail Failure Form RF1 (see Appendix 1) using the guidelines in Chapter 13 for each rail defect.
6. When the weld has been ultrasonically tested paint over the pink paint mark with blue paint if satisfactory and yellow paint if a defect is found.

   Each new wire feed weld should have been marked in pink flourescent paint by the welder after the weld has been completed.

C6-5.3.3 Alignment testing

1. Check that the weld has been ground to correct profile and that excessive grinding has not been undertaken
2. Test all new wire feed welds in plain track (not crossings) for top surface and rail alignment with a 1m straight edge as described in Section C5-4.
3. Complete a Weld Alignment Failure Form WAF1 (see Chapter 14) for each weld that does not meet alignment limits in Section C4-2.

C6-6 Testing of Rail Bond Welds

Where a defective or potentially defective Rail Bond weld is reported carry out an ultrasonic test for internal defects.

If any internal defects are identified classify them as for wire feed welding defects.

If molten metal has been deposited onto the rail foot and there is visible damage to the rail web or rail foot, no more than 0.5mm deep, the defect must be ground out. The priority for action is the same as a DWS.

If visible damage is deeper than 0.5mm classify the defect as a Defective Weld Small (DWS).

Where there is more major visible damage, classify the defect as a Defective Weld Medium (DWM). The defect can be removed with a weld, wide gap weld as necessary to remove all of the visibly damaged area and provided there is no other Cadweld within 300mm. Otherwise a closure is to be used.

C6-7 Completing a Welding Return

Record the following information about each weld in SmartWeld (or on the Wirefeed Welding Return Form WFR1 if the SmartWeld system is not available (See Appendix 4). The fields on the form are explained in Table 8.

Weld Testing Data	
Test Date	Enter date of test
Ultrasonic Pass	Circle YES or NO

Alignment Pass	Circle YES or NO
Defect Size	Circle S (Small) M (Medium) or L (Large)
Defect Location	Location of defect
Rail Fail ID	Number of rail fail form completed for this weld defect
Alignment Failure ID	Number of Alignment Failure form completed for this defect
RFD Operator's Name	Name of RFD Operator.
Signature	*(Not required in SmartWeld)*
Comments	Write down any comments relevant to the work

Table 8 - Information to be recorded on Wirefeed Welding Return

C6-8 Testing and marking of rail closures

Test any second-hand 53kg/m rail (full lengths or closures) before use as follows:

1. Examine ultrasonically using the procedures in Section C6-1.(Steps 1 - 3 only).
2. Check the rail heat number and manufacturers brand on the closure (the Heat number is usually the first character in the heat number).

   If:

   ~ NO defects of any detectable size are found, AND

   ~ there is NO evidence of inclusions, AND

   ~ the rail is BHP or AIS, AND

   ~ the Heat number does NOT contain the "A" character,

   mark the rail as suitable for re-use in main line by painting the rails with a WHITE stripe.

   If defects of any detectable size are found, or there is any evidence of inclusions, or if the Heat number contains the "A" character, mark the rail as scrap by painting the rails with a GREEN paint stripe.

   If the brand shows the rail is not BHP or AIS it is not to be used on main lines but may be used on sidings. Mark the rail with a BLUE paint stripe.

3. Mark the rail with a paint stripe about 200mm long on one side of the rail foot at each end of the rail length but leaving the end itself clear for about 200mm. For rails longer than 4 metres that are likely to be subsequently cut up into closures a paint a stripe every 3 metres along the rail.
4. Cut scrapped rails into lengths less than 2 metres. If there is any delay in carrying this out paint the rails with a GREEN stripe.

C6-9 Marking of testing details on the rail

Use a paint pencil or suitable long lasting marker to write required testing information on the rail.

C6-9.1 Marking on turnouts

Marking of testing details

Write your (operator) initials and date of testing on the top of the wing rail (away from wheel contact area) on each crossing that comprises part of turnout that has been tested.

Write these details also on any catchpoints, expansion switches etc. which are a part of a regular testing program.

Marking of defects found when testing turnouts

When a defect is found by ultrasonic or visual inspection by the Ultrasonic Rail Testing Operator spray the defect YELLOW and mark the type, size and location/extremities of the defect on the foot or gauge side face of the rail as appropriate. eg HWS-M.

C6-9.2 Marking on plain track

When a defect is found by ultrasonic or visual inspection by the Ultrasonic Rail Testing Operator spray the defect YELLOW and write the following testing details on the foot or gauge side face of the rail as appropriate.

- Your (operator) initials and date of testing. eg. JS 20/3/09.
- The type, size and location/extremities of the defect eg HWS-M.

When pre-testing for wire feed repairs, write the depth of the defect in mm on a suitable part of the rail.

C6-9.3 New Field Welds

Write the following testing details on the flange (foot) of the rail immediately adjacent to each new weld that has been tested:

- Your (operator) initials and date of testing
- The size, location or type of any defects found by ultrasonic testing. eg DW-M Foot.
- Weld alignment test details when a non-compliance has been found.

  Top of rail straightness,

  1. Weld tolerance dip WTD and the size S, M or L, eg WTDS.
  2. Weld tolerance peak WTP and the size S, M or L, eg WTPS.

  Side of rail straightness,

  3. Weld tolerance gauge narrow WTGN and the size S, M or L, eg WTGNS.
  4. Weld tolerance gauge wide WTGW and the size S, M or L, eg WTGWS.

Spraying of Welds

Spray all new welds on the weld on both the field side and gauge side of the weld to indicate whether they have passed or failed the ultrasonic test.

Spray over the pink luminescent paint on new wire feed repair welds.

Spray all new welds with two paint dots, one on each side of the weld on both the field side and gauge side of the rail to indicate whether they have passed or failed the alignment test.

Use BLUE paint for pass and YELLOW paint for fail.

Take care when spraying around the weld so that paint is not sprayed on the weld identification sticker.

Chapter 7 Ultrasonic testing of turnouts and special trackwork

C7-1 Testing requirements

1. Test the rails, crossings and switches of turnouts, catchpoints, expansion switches, diamonds and slips for internal rail defects. The testing is separated into three individual tests as follows:-

Head
Use a 70° probe to examine the rail head area for defects of a transverse nature only. Use the testing procedure detailed in Section C8-2 to conduct the test.
Web and flange
Use a 38° probe to examine the rail web and that part of the flange (foot) directly beneath the web. for defects of a transverse nature, including bolthole fatigue and weld defects. Use the testing procedure detailed in Section C8-5 to conduct the test.
Head, Web and flange
Use a 0° Probe to examine the rail head, web and flange for defects of a vertical or horizontal nature, including bolthole fatigue and longitudinal defects. Use the testing procedure detailed in Section C8-2.6 to conduct the test.

Important
Ultrasonic testing operators need to be careful when testing near insulated joints to ensure that no aspect of the testing procedure causes an electrical connection across the joint.

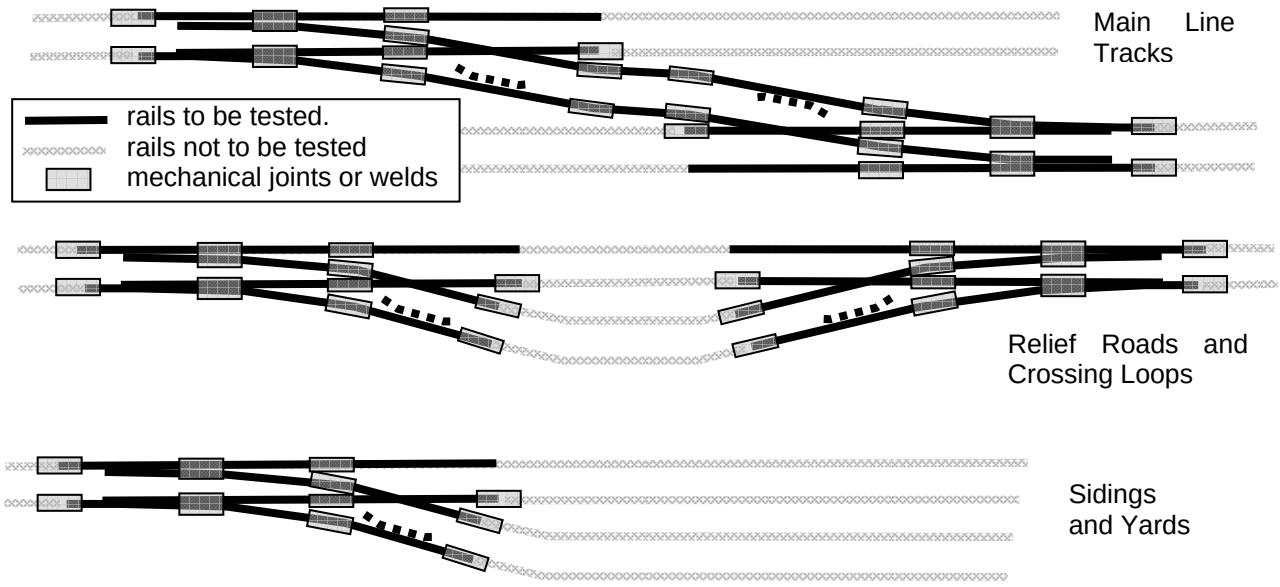
Main Line Tracks
rails to be tested.
rails not to be tested
mechanical joints or welds
Relief Roads and Crossing Loops
Sidings and Yards

Figure 12 - Locations for ultrasonic testing in turnouts

2. Examine the rails and track components as shown in Figure 12 and Figure 13.

   Test the through main line with the 70° and 0° probes from the far end of the stock rail through to the location on the main line rail which is adjacent to the furthest end of the crossing. This includes both up and down rails. Test in both testing directions with the 70° probe.

   Test the full stock rail and switch rail past the heel block to the end of the rail with all 3 turnout probes. Test in both testing directions with the 70° and 38° probes.

   Test all mechanical joints (including both main line and turnout line joints, within the area

bounded by the extremities of the turnout) with 0° and 38° probes.

Test mechanical joints at both ends of any rail which butts to the stock or switch rails with 0° and 38° probes.

Test bolt holes in all check rail carriers with a 38° probe.

Test any welds

Test full length of crossings (both wing and point rails),

Test the full extent of the turnout as indicated above using a testing stick.

Test load bearing portions of the crossing including the wing rails and nose of the crossing by hand with all three probes indicated.

Give special attention to locations which have been built-up using a wire feed or other welded repair.

When testing turnouts with the testing stick you must use the audible monitor when using a 70° probe.

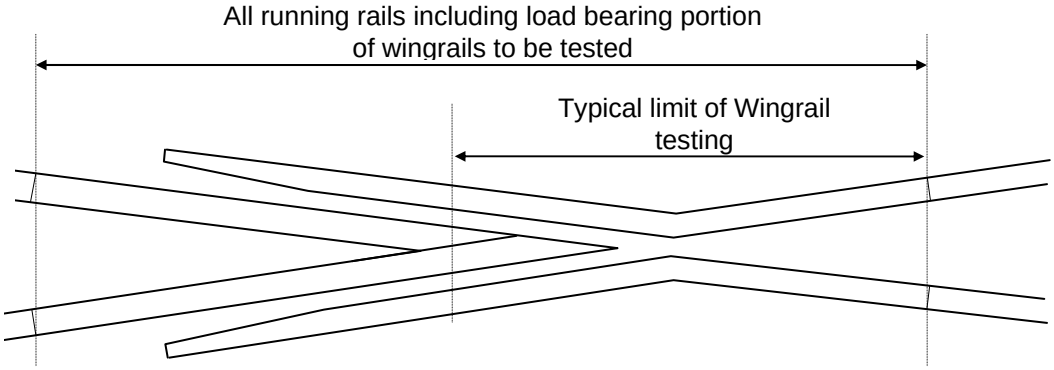

Figure 13 - Crossing and wingrail testing

3. Examine the heel block area and adjoining closure rail at the heel joint of heel jointed switches for crack predictors. (Crack predictors are defined as indications with probe movement in the range of 10mm to 19mm, including bolthole and head/web fillet indications). Record any new crack predictors.

   At pumping rail ends when testing with a 0° probe there is often loss of back wall echo and horizontal surface indicators from lamination due to rail end battering. In addition rail ends at the joint are often proud on one side which prevents the probe sitting properly as it passes over the joint. This combination of problems makes it difficult to detect ‘under size’ horizontal head/web indicators.

   Look as carefully as you can at the ‘rail end extremity’ with the 0° and 38° probes. Ifyou see any sign of a head/web indicator, or undersize bolt hole crack, at joints associated with switches classify the joint as an MJS, for removal of the plates and testing with dye penetrant for head/web cracking and/or minor bolt hole cracks. All cracks found no matter how small, require replacement of the rail end.

4. Advise the Team Manager of the heel joint locations where crack predictors have been detected by completing a Weekly Defect Summary Report (Form 2).

5. Mark locations with crack predictors by paint marking the rail with a horizontal pink stripe on web of the heel joint.

6. Retest the switch and adjoining closure rail at the heel joint, where crack predictors have been recorded at three monthly intervals. Retest previously recorded crack predictors and compare with the previous test results. Record any new crack predictors.

7. Report to the Team Manager if a 3 month retest of crack predictors shows both an increase in the probe movement obtained from the indicator compared to the previous test and with a probe movement which has reached at least 15mm. This should then be regarded as a strong crack predictor. If there appears to be growth in a previously detected crack predictor, which is indicating as a strong crack predictor, remove the plates and locate any cracks using visual and dye penetrant inspection. Where any visible cracks are located, replace the rail end.

8. Continue 3 monthly retesting of the switch and adjoining closure rail at the heel joint, where crack predictors have been recorded, until the switch or closure rail is replaced.
9. Test all switch tips using Dye Penetrant testing as detailed in Section C7-2.
10. Examine switches and crossing for visually detectable defects.

    Inspect the switch foot and web of the switches for any signs of cracking from about 1.5m to 3m back from the tip. Wipe off any surface dirt or grease from the outside of the switch first.

    Visually examine the inside of the open switch.

    Make arrangements to have the points reversed so that the inside of the other switch can also be visually examined.

CAUTION:
Staff must not put any part of their body or anything else between the switch and the stockrail unless appropriate protective arrangements are made. Worksite supervisors should review the protection required but it would at least require having the points secured and clipped by the signaller.

11. Examine crossings with a hardened alloy insert such as manganese or chrome vanadium for characteristic horizontal defect which is the typical type of failure that occurs with this type of crossing.
12. Examine monobloc crossings using the procedure detailed in Chapter 18.
13. Establish the size of defects using the sizing procedures in Chapter 10 and by reference to the defect limits in Section C4-6.
14. Take appropriate action if defects require urgent attention
15. Complete a Rail Fail Form RF1 (see Appendix 1) using the guidelines in Chapter 13 for each rail defect.
16. Record the detail of all turnouts tested and defects found on the Monthly Test Return Form MRTR1 (see Appendix 5). At the end of each month return the form to Team Manager for recording and forwarding to Rail Inspection Services.
17. Mark your initials (identification) and the date of testing on the top of the crossing related to the turnout in a location not effected by the wheels of a train.

C7-2 Dye penetrant testing of switch blades

C7-2.1 Equipment

Suggested equipment		Stock Code
1. Cleaning Solvent.	(Aerosol)Ardrox, 9PR50C (Green Can)	001309467
2. Dye Penetrant	(Aerosol) Ardrox, 907PB Store upright.(Red Can)	001309442
3. Developer	(Aerosol) Ardrox,9DlB Store upright(Blue Can)	001307891
Product also available from:	Chemetall, 23 Amax Ave Giraween. Phone 98960700 Fax 98960634	
Also Required	Nitrile Gloves 33 cm (Protector Safety) Chemical Safety Glasses (Protector Safety) Wire brush / 25mm paint brush / scraper Cleaning rags, Turps or degreaser (possibty required).	
Note:	Order at least 2 cans of Cleaning Solvent per can of dye.	

C7-2.2 Safety Requirements

To carry out this procedure:

- Wear Chemical Safety Glasses.
- Keep both hands and feet well clear of the gap between the switch blade and the stock rail.
- Be aware of sharp slivers when using rags to wipe the top of the blade.

– Wear gloves to avoid getting dye on the hands and to help reduce the risk of cuts.

Note: Aerosols inside a vehicle must be kept out of direct sunlight and the vehicle kept ventilated at all times. Due to risk of explosion, keep aerosols in an Esky to insulate from excessive heat.

C7-2.3 Surface cleaning

1. Clean the surface to be tested.

   Carry out cleaning on the side of the switch blade facing the 4 foot from the point end of the switch blade back at least 750mm and from the top of the blade to a depth of 70mm.

   Attachments to the side of the switch will set some limit to the depth of the area that can be tested.

   Clean the surface to remove all grease/heavy rust/dirt etc with a scraper/brush/rag as required.

   It may sometimes be necessary to use a brush and turps to remove a heavy grease layer from the surface of the switch. Use spray solvent (Green Can) for final cleaning. Allow solvent to dry off.

C7-2.4 Apply the Red Dye Penetrant. (Red Can)

1. Shake the aerosol can for a few seconds before use.

Warning:
The dye is very difficult to remove from clothing and hands.

2. Spray Dye Penetrant onto the test area from the point on the blade where wheel transfer occurs (where shiny marks start), back at least 750mm and to a depth 70mm from the top of the blade. Use a side to side sweeping motion to get a complete and thorough cover of the surface. Do not clear the nozzle of the aerosol.
3. Leave the red dye on the switch blade for a dwell time of 20 minutes.

   Trains running over the blade during this time will assist the test and are not a problem.
4. Clean the surface of the test area thoroughly to remove all residue dye.

   Wipe off excess dye with a dry rag. Water can be sprayed lightly onto the surface of the rail as another means of removing the excess surface dye.
5. Spray the cleaning solvent (Green Can) onto a piece of rag and thoroughly wipe all remaining dye from the surface. Do not spray cleaning solvent directly on to the test area.

   Final clean should be with cleaning solvent on a rag (Green Can).

Always keep both hands well clear of the gap between the switch blade and the stock rail.

Note: Dry rags previously soaked with solvent are volatile even when dry. Used rags should be kept wet with water until disposed of at the depot. Do not leave dried solvent rags in a vehicle.

C7-2.5 Apply the White Developer (Blue Can)

1. Shake the aerosol can before use (about 15 seconds).
2. Apply the White Developer. (Blue Can) on to the blade to cover the full test area. The aerosol can should be sprayed from a distance of about 25cm from the surface. Use a side to side sweeping motion to get an even, light and comp!ete cover of the surface. Do not clear the nozzle of the aerosol.

C7-2.6 Check for defect indications

1. Allow 3 to 5 minutes for any indications to develop. If any cracks are present in the test area of the switch blade, the cracks will appear as a distinct red line.

   A mirror may be needed away from the point to look for cracks beneath the rail head.

Chapter 8 Rail Flaw Testing Guidelines

C8-1 Introduction

At the beginning of each day before doing any kind of testing check the flaw detector for proper function and calibration using the calibration procedures in Section C9-1. Check that individual probe/test setting is correctly selected and set for zero and depth calibration when testing.

Use ALL probes designated for use in the testing applications detailed in Table 9.

Component or defect	Probes to be used
Aluminothermic welds	WB70, WB35, SEBO & VS70,
Turnouts	WB70 with audible gate on, WB35 & SEBO
Wire Feed Welds	WB70 & SEBO Size Small indications with a VS70
Boltholes close to a newly completed wire feed welds	WB35
Vertical Splits	Size with K4NF

Table 9 – Use of probes for testing

C8-2 Testing the head of the rail with a 70° probe (WB70-2E)

Note: Set the zero end of the base line using the procedure for 'Zero Delay for 70° & 38° probes in Section C9-2.1

C8-2.1 Setting up procedure

The signal from the bottom corner of the rail head has to be set on '10' along the base line of the screen. This adjustment requires using the 70° Angle Plate in conjunction with the Range (depth) Control.

1. Line up the blade of the 70° angle plate with the bottom corner of the head at a rail end and place a vertical mark on the side of the rail head where the other end of the blade meets the top of the head.
2. Place the 70° probe on the top of the rail pointing toward the rail end. Line up the beam centre of the probe with the mark determined by the angle plate. Point the probe slightly outwards toward the corner of the rail head and adjust the signal from the bottom corner of the head onto '10' along the base line of the screen. (See Figure 14). This adjustment is made with the Range (depth) Control. The left hand side of signals should always be used when setting the position of the signal on the screen.

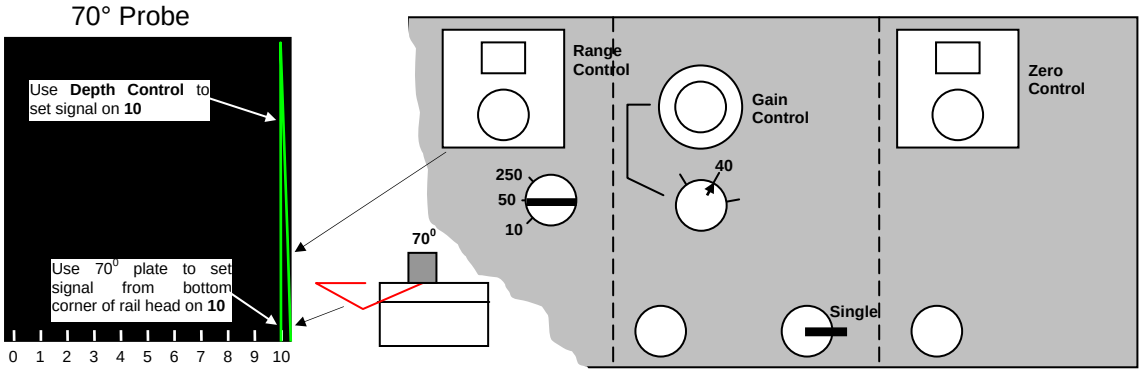

Figure 14 – Setting up a 70^0 probe

The screen is now set for finding transverse indicators in the head of the rail.

The screen from '0' to '10' represents the rail from the top to the base of the head.

3. Set the scanning gain by adjusting the Gain Control until the 'grass' level is 20%, (1/5th) screen height as the probe is moved over the surface of the head.

   If this gain level does not produce an indication that reaches 80% screen height then the indication should be disregarded unless it is established as a defect with another probe.

The Screen is now set for locating Defects including Transverse Defects and Defective Welds in the head

C8-2.2 Scanning for defects with a 70° probe

1. Move the probe in a longitudinal direction along the top of the rail head.
2. Always scan in both testing directions.

   Scanning for Transverse Defects:

   Make a scanning pass in both longitudinal testing directions along the full length of the rail to be tested slightly favouring the gauge corner side of the head.

Guidance Notes
1. Surface horizontal laminations such as occur at wheel burns, battered crossing noses and squats can often give a similar display on the screen to a transverse defect. Be careful to avoid confusing these surface wave reflections with a TD.

   Scanning for Weld Defects:

   With the probe pointing towards the weld, make three adjacent longitudinal passes in both testing directions along the head. Make the passes from at least 150 mm back from the weld through to just past the weld and cover the full width of the head. Keep the probe should be parallel with the side of the head.

3. If a potential defect is present in the head of the rail then a signal will travel along the screen as the probe is moved. The testing window for this test is from '0' to '10' along the base line of the screen. If an indication is present in the testing window then it should be sized using the Sizing Procedure in Chapter 10 to determine if a defect is present in the rail.

C8-2.3 Additional setting up procedure prior to assessing indications found in the lower part of the head when testing aluminothermic welds.

Note: Due to head wear, reflected signals from the overflow of the weld metal underneath the outer base of the head may display on the screen. These indications can be misinterpreted as a defect at the '10' end of the screen. A re-check of the position of the corner at the base of the head is therefore essential.

1. Choose a testing direction and line up the blade of the 70° angle plate, with the corner at the base of the head created by the far side corner of the weld.
2. Place a vertical mark on the side of the rail head where the other end of the blade meets the top of the head.
3. Repeat this operation in the opposite testing direction. (See Figure 15).

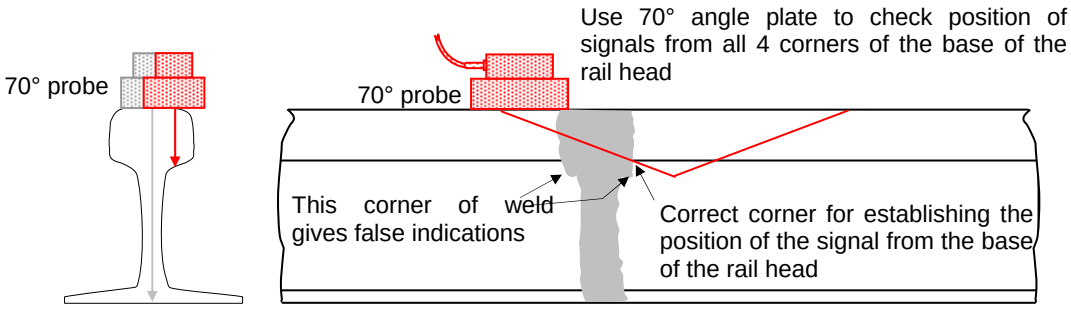
70° probe
70° probe
Use 70° angle plate to check position of signals from all 4 corners of the base of the rail head
This corner of weld gives false indications
Correct corner for establishing the position of the signal from the base of the rail head

Figure 15 – False defect indication from bottom corner of head

4. Place the 70° probe on the top of the rail pointing toward the weld with the beam centre of the probe in line with the mark determined by the angle plate.

5. Move the probe to one side of the head and point the front of the probe slightly outwards toward the corresponding corner of the weld.
6. Adjust the signal from the bottom far corner of the weld onto '8' along the base line of the screen. This adjustment is made with the Range (depth) Control.
7. Repeat this procedure on the opposite adjacent corner of the weld. Do not readjust the test range again until all 4 corners of the weld have been displayed on the screen and their position noted.
8. Turn the probe to the opposite testing direction and repeat the procedure again. The corners on both sides of the weld should have displayed on the screen on '8' approximately.
9. Choose the best of these corner signals and set the corner signal on '10' along the base line of the screen. This adjustment is made with the Range (depth) Control. The left hand side of signals should always be used to set their position on the screen. Three of the 4 corners should display on the screen in approximately the same place. If there is no consistency then the weld may be defective and another weld or a rail end with a similar level of head wear should be found.

   The screen is now set for assessing indicators in the head of the weld.

   The screen from '0' to '10' represents the rail from the top to the base of the head (See Figure 16).

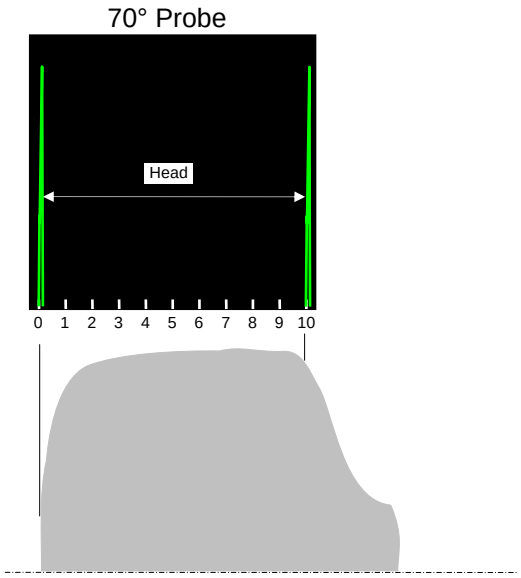

Figure 16 – Setting bottom of rail head

Guidance Notes

1. Take care when using the WB70 probe for testing the head of welds as small shoulders left on the side of the head after grinding can give spurious indicators. Avoid twisting the probe off parallel during testing runs.
2. Surface irregularities in newly ground rail may cause difficulties in testing because of rocking of the probe. (See Figure 17).

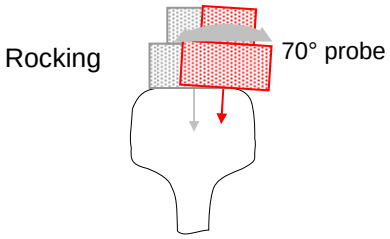

Figure 17 – Probe rocking

C8-2.4 Determining the location (longitudinal alignment/position) of defects with a 70° probe

Defects found with an angle probe do not generally lie under the probe but are located in front of the probe. For the removal of defects it is necessary to determine the longitudinal alignment of the transverse defect in the head.

1. Move the probe along until the left hand side of the defect signal is on '5' on the base line of the screen. A signal on '5' using the above settings is a reflection from halfway down the head from the top of the rail.
2. Place a mark on the rail in line with the beam centre of the probe.
3. Lift the probe off the rail.
4. Place the top end of the blade of the 70° angle plate in line with the mark and draw a line along the blade of the plate downwards toward the base of the head.
5. Draw a horizontal line half way down from the top of the head intersecting the line from the plate.
6. The point where the two lines intersect is the longitudinal alignment of the transverse indication.

C8-2.5 Determining the location (depth) of defects with a 70° probe.

For the removal of defects it is often necessary to determine the depth of the lowest extremity of a transverse defect in the head. This information is needed for assessing the practicality of using a Wire Feed Repair Weld.

When the setting up procedure in Section C8-2.1 has been used, each unit along the base line of the screen represents an increment of depth equal to 1/10th of the height of the head.

- For 60kg rail a practical average height is 40mm giving each unit on the screen a value of 4mm.
- For 53kg rail a practical average height is 35mm giving each unit on the screen a value of 3.5mm.

1. When sizing is carried out on a defect note the position of the signal on the screen at the lowest extremity of the defect.
2. Multiply the unit number, (base line number) to the left of the indication by 4mm or 3.5mm according to the head size above to determine the depth of the lowest extremity of the defect.

C8-2.6 Scanning for defects in wire feed welds with a 70° probe

1. Move the probe in a longitudinal direction along the top of the rail head scanning for:
   - ~ Transverse defects in the head that were not removed by the welder, prior to welding, ie Engine Burn Defects or other Transverse Defects.
   - ~ Transverse indications due to lack of fusion in the wire feed weld.
2. Probe the repair area plus 100mm each side along the top of the rail head.
3. Make multiple passes with the probe in each testing direction paying particular attention to weld depth area (i.e. weld/rail interface).
4. If a transverse indication is of standard TD-S size (40mm probe movement or more) size the defect with a 70° probe using the sizing procedure in Section C10-6.

   If the probe movement of the defect is less than 40mm, size the defect with the twin 70° probe (VS70-04E), using the sizing procedure in Chapter 10.

Guidance Notes
1. If a transverse or horizontal defect is found in either a new or old wire feed weld always designate the defect as a DWFW - S, M or L. Do not call these defects a TD or HSH when writing out the Railfail form

C8-3 Testing the web and centre foot of the rail with a 38° probe (WB35 2E)

Note: Set the zero end of the base line using the 'Zero Delay for 70° & 38° probes' procedure in Section C9-2.1.

C8-3.1 Setting up procedure:

1. Place the probe on top of the rail head with the probe centred over the top of the web.
2. Move the probe along the rail in a longitudinal direction. Set the left side of the reflected 'rolling' signal from the base of the rail on '10' along the base line of the screen. (See Figure 18). This adjustment is made with the Range (depth) Control.

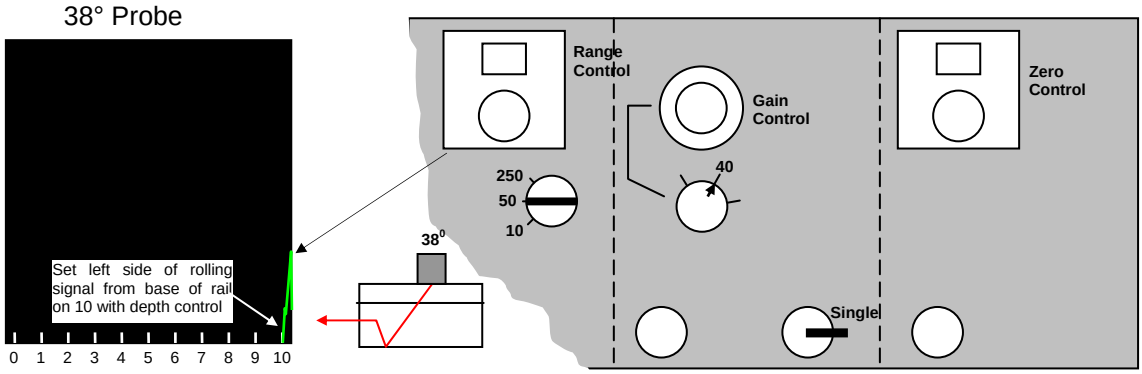

Figure 18 – Setting up a 38° probe

The screen is now set for finding transverse and diagonal indicators in the web and centre foot of the rail.

The screen from '0' to '10' represents the rail from the top to the base of the foot. (See Figure 19

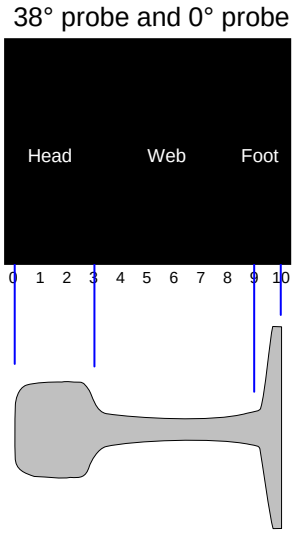

Figure 19 – Setting rail height

3. Set the scanning gain by adjusting the Gain Control until the 'grass' level is 20%, (1/5th) screen height as the probe is moved over the surface of the head.

   If this gain level does not produce an indication that reaches 80% screen height then the indication should be disregarded unless it is established as a defect with another probe.

The Screen is now set for locating defects including Bolthole Defects, Defective Welds in the web and transverse indicators in the centre foot of the rail.

C8-3.2 Scanning for defects with a 38° probe

1. Move the probe in a longitudinal direction along the top of the rail head.
2. Always scan in both testing directions.

Scanning for Bolthole Defects

Make a scanning pass in both longitudinal testing directions along the full rail length in the bolthole areas with the probe centred over the top of the web. Test slowly and a obtain a signal from each bolthole. Defect signals will occur on the screen in addition to the signals from the boltholes.

If a bolthole fails to display a signal on the screen, the reason must be determined.

Guidance Notes

1. Test boltholes slowly with both the 38° and 0° probes. *Figure 20* shows likely probe locations relative to bolthole cracks

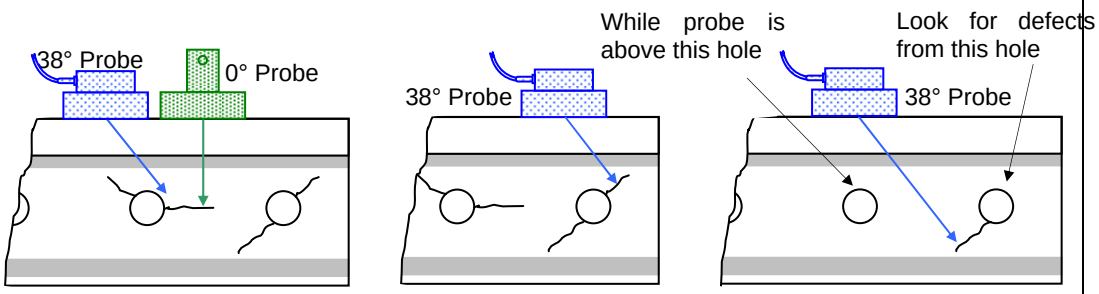

Figure 20 – Scanning for bolthole defects

Guidance Notes

1. Bolthole cracks that propogate from the lower half of the 1st bolthole downwards towards the rail end can only be found when using a 38° probe by skip testing of the face of the rail end onto the defect. Indications will occur between 6 and 10 on the baseline. See Figure 21).

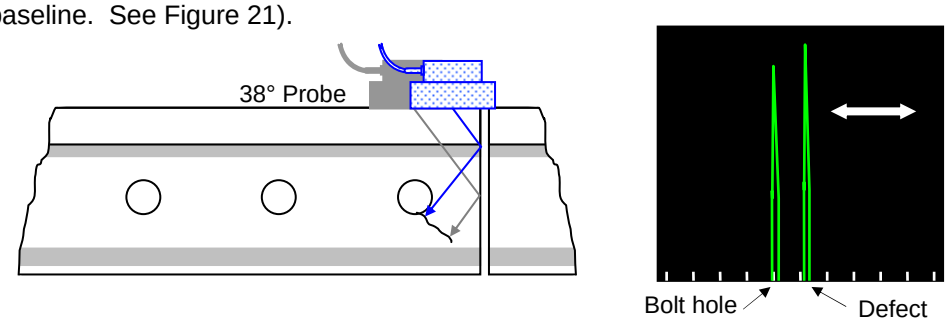

Figure 21 – Skip testing for bolthole defects

2. Sometimes you can miss a defect at the first bolthole due to rail end batter or a proud joint.. If the bolthole is not displayed you may mistake a small defect for the first bolthole. (See Figure 22).

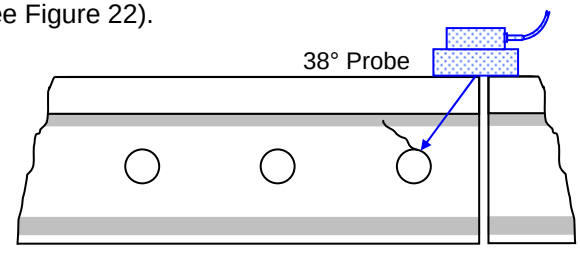

Figure 22 – defects near the first bolthole

Scanning for Weld Defects

With the probe pointing towards the weld make two (2) longitudinal scanning passes in both testing directions with the probe kept centred over the web. Make the passes from at least 150

mm back from the weld through to just past the weld. Keep the probe parallel with the side of the rail.

3. If a potential defect is present in the web, centre foot or a bolthole then a signal will travel along the screen as the probe is moved. The testing window for this test is from '0' to '10' along the base line of the screen. If an indication is present in the testing window then it should be sized using the Sizing Procedure in Section C10-7 to determine if a defect is present in the rail.

Guidance Notes

1. Horizontal defects are often located with a 38° probe. Size these indications with a 0° probe using the Sizing Procedure in Chapter 10.

2. Indications found with a 38° probe between '0' & '2' along the base line of the screen indicate a potential defect in the head. Size these indications with a 70° probe using the Sizing Procedure in Chapter 10 to determine if a head defect is present and to determine the size of the defect.

3. When testing with a 38° probe a couple of signals are often obtained on the base line of the screen between 4 and 2 as the beam from the probe passes through the top fillet area. These signals should be ignored unless they are a continuation of a signal that has started from lower down in the rail or they continue past 2 up into the head area of the rail. (See Figure 23).

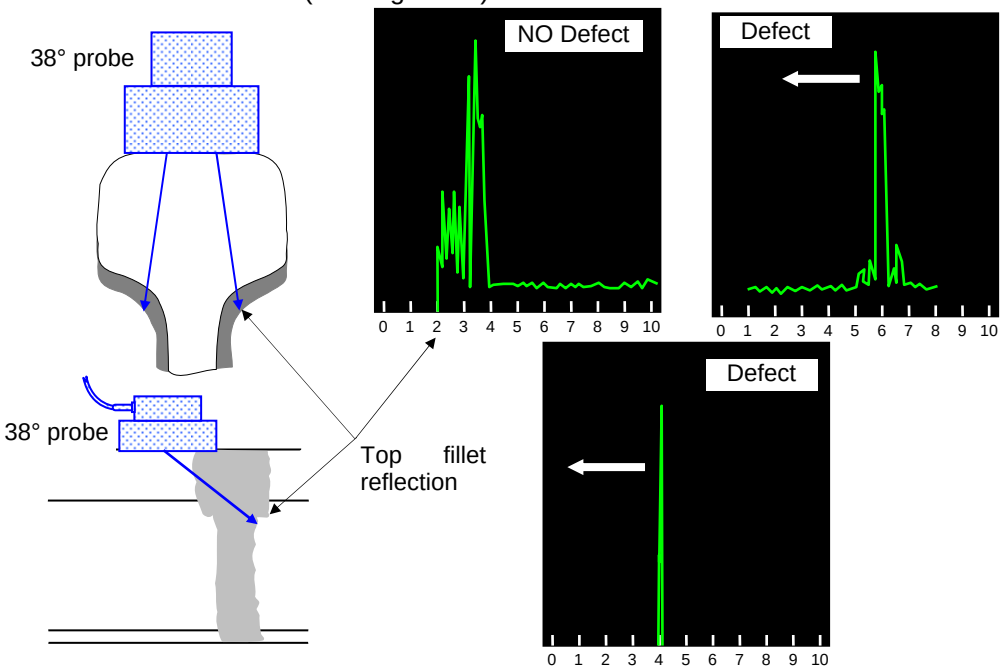

Figure 23 – Signals from bottom corner of rail head

C8-4 Testing the foot of an aluminothermic weld with a twin 70° probe (VS70-04E)

C8-4.1 Setting up procedure

Use the USK7/S rail flaw detector unit setting up procedure detailed in Section C9-1.1.1 to set up the VS70-04E Probe.

1. The flaw detector is now set up to read the distance in front of the probe of any indication on the screen. Each major unit on the screen represents a distance of 10mm. eg. When the left-hand side of a signal is at '4' on the base line of the screen then the reflector is located 40mm from the front of the probe.

2. This measurement can be used to confirm the relevance of an indication.

   eg. If a signal appears on '4' on the base line of screen, measure 40mm from the front of the

probe. If this measurement indicates the opposite side of the weld then the indication is confirmed as a non-defect reflector from the far corner of the weld.

If the 40mm measurement falls within the relevant range for the alignment of the fusion plane then the indication is a potential defect and should be sized (see steps below).

The relevant range for the alignment of the fusion plane is from the transverse near edge of the external weld metal to the transverse centre of the weld.

C8-4.2 Scanning for defects with a twin 70° probe

1. Ensure that the four foot (flange) surfaces adjacent to the weld are properly cleaned to enable good coupling of the probe to the rail. Maintaining water saturation of the surface is also essential for this test.
2. Set the scanning gain. Place the probe on the flange of the rail adjacent to the weld to be tested and while moving the probe adjust the 'grass' level to 20% (1/5th) screen height in the primary part of the testing window ie (3 to 5 on the base of the screen) with the Gain Control.
3. Point the probe toward the weld to be tested.
4. Use a long testing sweep to make several longitudinal passes from 80mm back through to 20 mm from the transverse edge of the weld. Cover the full width of the flange with the testing passes. Keep the probe parallel with the edge.
5. Repeat this procedure on all four of the flange surfaces adjacent to the weld.
6. If an indication is obtained on the screen it is necessary to determine its relevance before sizing is carried out. The following criteria must be met.

   i. The indication must appear within the appropriate 'testing window'. When the probe is moved back and forth a significant signal must travel across the base line of the screen for at least one major unit between '3' and '7' to qualify for sizing.

   ii. The signal on the screen indicates the distance from the front of the probe to the reflector in the weld. This distance must be measured with a rule. The measured distance must put the reflector within the near half of the weld for the indication to qualify for sizing.

   iii. The primary part of the test window for this test is from 3 to 4 along the base line.

   All indications travelling from 3 to 4 must be sized.
7. If the indication complies with the criteria in Step 6, both (i) and (ii) or part (iii), then the defect should be sized using the Sizing Procedure in Chapter 10.

Guidance Notes

1. The strongest reflections from lack of fusion often occur between 4 and 3 along the base line of the display. Special attention should be given to this part of the testing window. It is, however, essential to disregard indications which display between 3 and 0 along the base line of the screen as these are typically due to surface wave reflectors from the weld and are not a defect indication.

2. Make sure you test right to the edge of the rail foot. A slight overlap of the edge of the foot is OK

3. Special care is needed to detect defects extending from the edge of the web outwards underneath the bottom fillet radius. Signals in this area are lost because the probe cannot sit on the radius. If any indication displays strongly on the screen in the testing window as displayed in Figure 24 but drops due to the probe lifting off on the radius, the weld should be classified as a DW-M Foot unless the sideways probe movement has already qualified the defect as a DW-L.

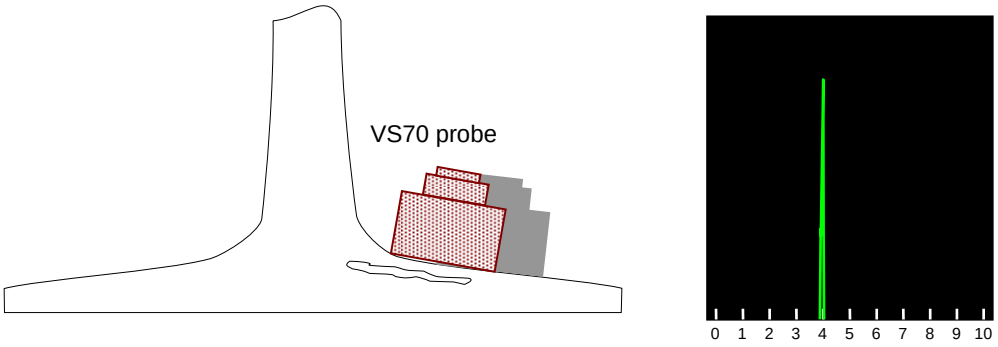

Figure 24 – defect under bottom fillet radius

C8-5 Testing the full rail with a twin 0° probe (SEB-2 0)

C8-5.1 Setting up procedure for twin 0° probe (SEB-2 0)

1. Place the probe on the top of the rail with both the sending and receiving probe aspects directly over the web.

2. Locate the back wall echo from the base of the foot and set the signal on 9.5 on the base line of the screen with the Range (Depth) Control. (See Figure 25).

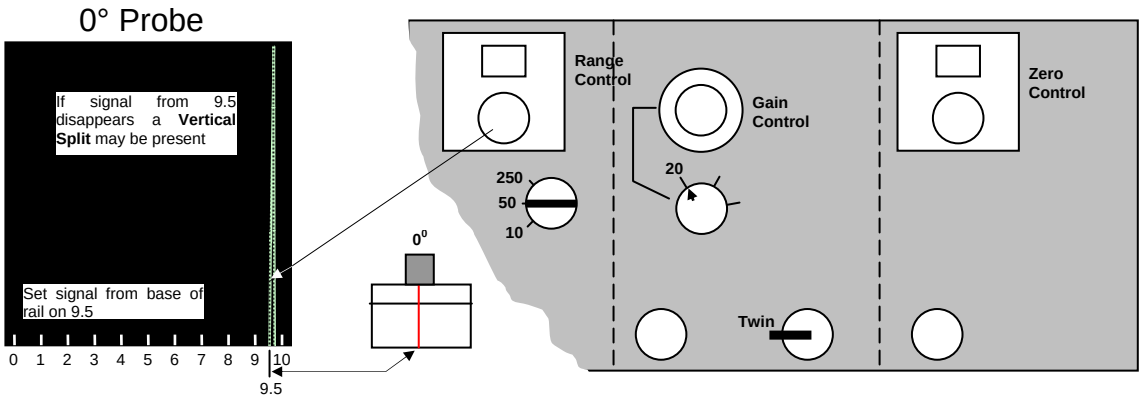

Figure 25 – Setting up a twin 0° probe

3. Adjust the Gain Control until the 'Grass' is 20% (1/5th) screen height.

4. Set the probe 'Zero' with the Pulse Delay Control using the calibration procedure in Section C9-2.2.

The Screen is now set for locating Horizontal and Longitudinal Vertical defects in the head and web of the rail.

The screen from '0' to '10' represents the rail from the top to the base of the foot. (See Figure 19).

C8-5.2 Scanning for defects with a twin 0^0 probe

1. Move the probe in a longitudinal direction along the rail keeping the probe centred over the web.

Scanning for horizontal defects

Horizontal defects will be indicated by a reflected signal between 0 and 9.5 on the base line of the screen.

This type of defect displays on the screen as a strong signal. The position of the signal along the base line of the screen is determined by the depth of the defect and determines its defect name.

Eg. HSH '0 to 2', HWS '2 to 3½', HSW '4 to 7', FWS '7 to 8'. (See Figure 26)

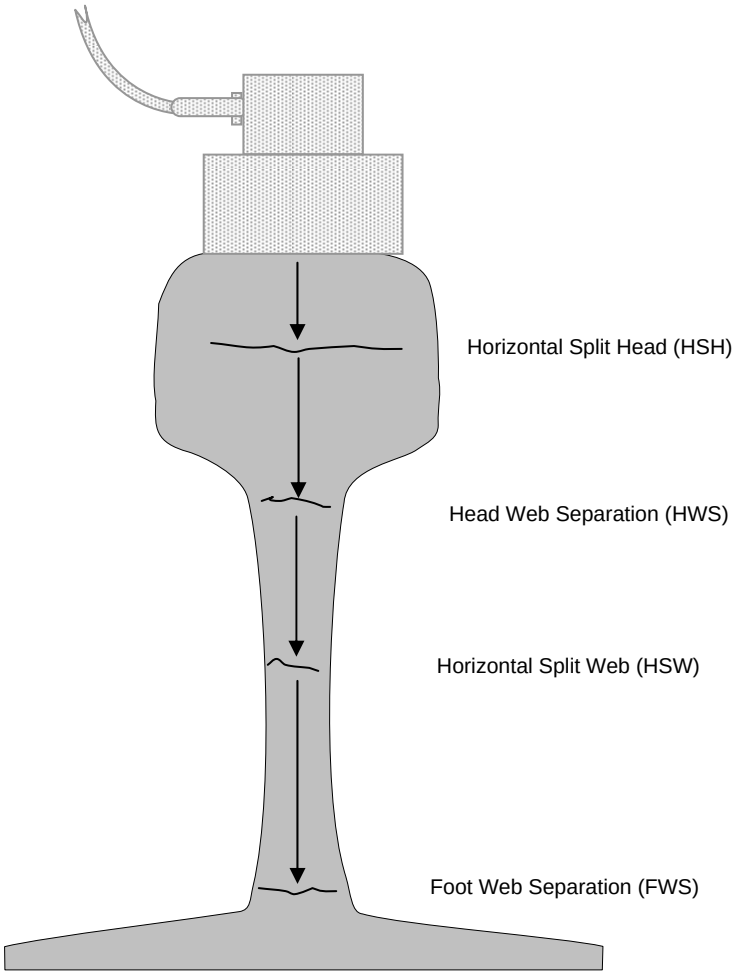

Figure 26 - Horizontal Splits in Head and Web

Note: Horizontal defects close to the top of the rail will have several repeat signals. The first signal indicates the depth of the defect.

Size horizontal indications using the 'last significant echo method' detailed in Chapter 10.

Scanning for vertical defects

This type of defect does not display a reflected signal from the defect on the screen.

The presence of a Vertical Split is indicated by a drop in the back wall echo. The strong signal from the base of the rail drops below the top of the screen or drops completely.

If this occurs a 0° probe such as a K4NF should be placed on the field side vertical face of the head to check for a Vertical Split Head and on the side of the web to check for a Vertical Split Web using the procedure in Section C8-7.

If no vertical spit is present, then determine which of the other causes indicated in Section C8-6.2 accounts for the drop in back wall echo.

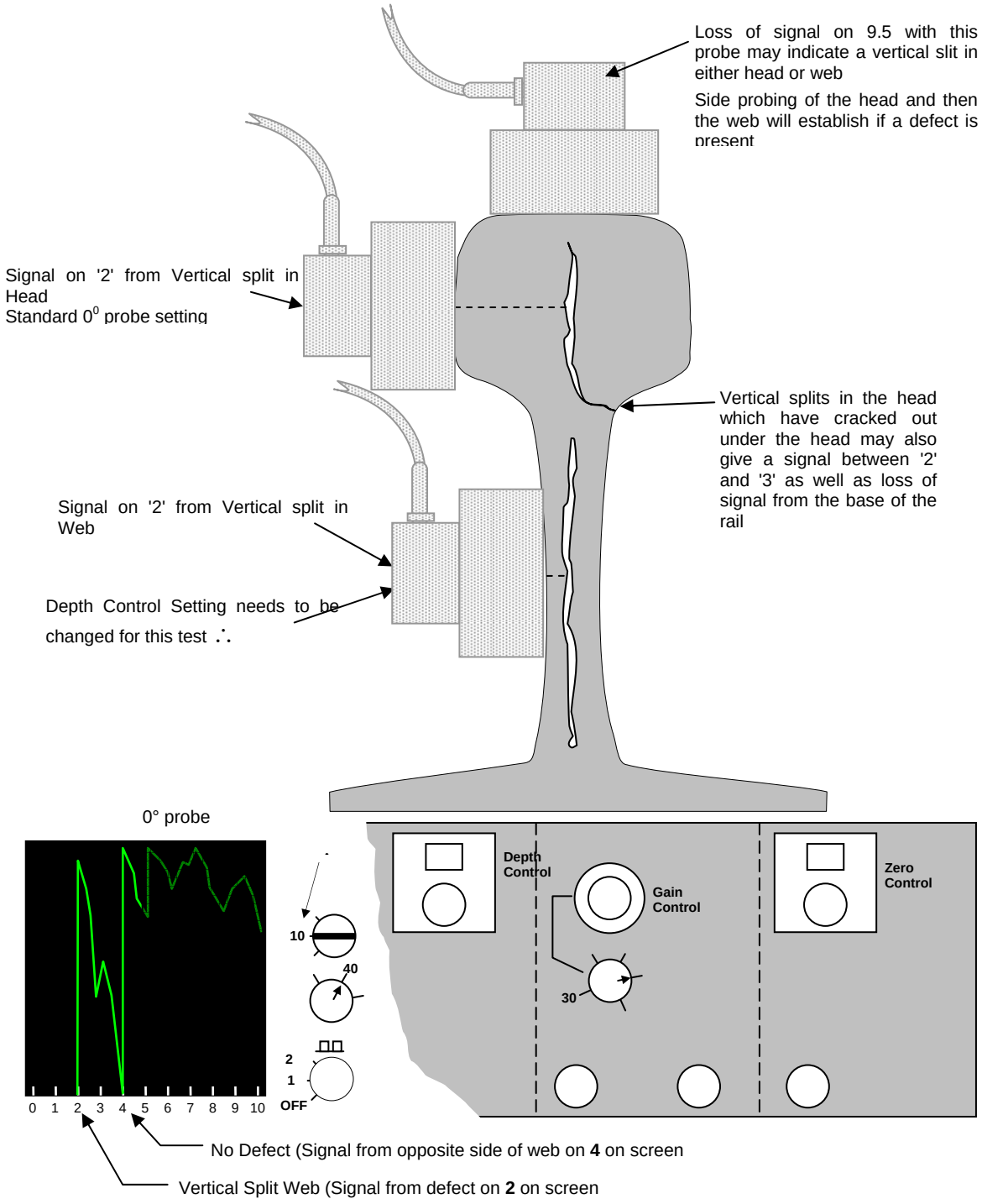
Loss of signal on 9.5 with this probe may indicate a vertical slit in either head or web
Side probing of the head and then the web will establish if a defect is present
Signal on '2' from Vertical split in Head
Standard 0⁰ probe setting
Vertical splits in the head which have cracked out under the head may also give a signal between '2' and '3' as well as loss of signal from the base of the rail
Signal on '2' from Vertical split in Web
Depth Control Setting needs to be changed for this test ∴
0° probe
0 1 2 3 4 5 6 7 8 9 10
10
40
2
1
OFF
Depth Control
Gain Control
30
Zero Control
No Defect (Signal from opposite side of web on 4 on screen
Vertical Split Web (Signal from defect on 2 on screen

Figure 27 - Vertical Splits in Head and Web

2. Variations from the standard signal presentation on the flaw detector screen should be investigated as a potential defect.

   These potential defects should be located and sized with the most appropriate probe using the Sizing Procedure in Chapter 10 to determine whether they qualify as a defect.

   Only Horizontal defects should be sized using a twin 0^0 probe. Vertical splits should be sized with a miniature 0^0 probe.

Guidance Notes

1. It is always essential to determine the reason for a drop in the signal height of the back wall echo (base of rail signal). See Section C8-6.2 – 'Back Wall Echo' for reasons other than defects that cause the back wall echo to drop in height.

2. If a loss of signal height occurs, then a second test must be conducted to establish the presence of a vertical split in the head or web.

   This is carried out by testing from the side of the head for a VSH and from the side of the web for a VSW. A miniature 00 probe is used for this purpose. See separate setting up and testing instructions for this procedure in Section C8-7.

3. The lower end of a VSH often turns horizontal and breaks out underneath the head in the top fillet area. When this occurs a similar signal to a HWS is displayed on the screen between 2 and 3½. When any HWS signal indicates on the screen, always carry out a 'side of head' test for a VSH.

4. Follow up testing stick indicators with hand testing

   If a section of rail has loss of back wall echo when testing with the stick, retest the suspect length with a hand probe, as it is easier to manipulate a hand probe and therefore maximise the back wall echo.

   If a back wall signal exceeding the top of the screen can be obtained with the twin 0^0 hand probe then the rail is satisfactory

5. This probe is essential for finding Gassing in an aluminothermic weld. A 38° probe will often give a very poor indication from gassing (See Figure 28).

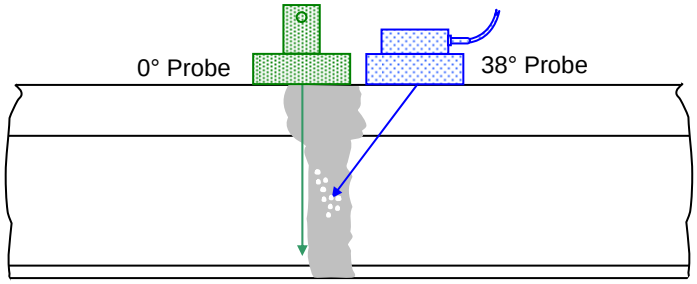

Figure 28 – Scanning for gassing defects

6. Use the SEB 0 probe with the gain slightly higher than usual and look for complete loss of back wall echo from the base of the weld continuing throughout the width of the weld. Return the grass to normal scanning gain and check for any horizontal cracks associated with the weld.

7. **Confirming Gassing Defects with a 0° Probe.** If indications that are similar to gassing i.e. 'multiple simultaneous signals' are found in a weld with the 70° or 38° probes but there is no complete loss of backwall echo with the **0**° probe, disregard the indications. Make sure however that the indication is like a typical gassing display and not a lack of fusion indication.

C8-6 Setting up SEB0 for testing depth of horizontal Indicators

1. Place probe on field side of unworn rail head
2. Set reflected signal from opposite side of the head (back wall echo) on '7' on the base line of screen. (Head width is 70mm)

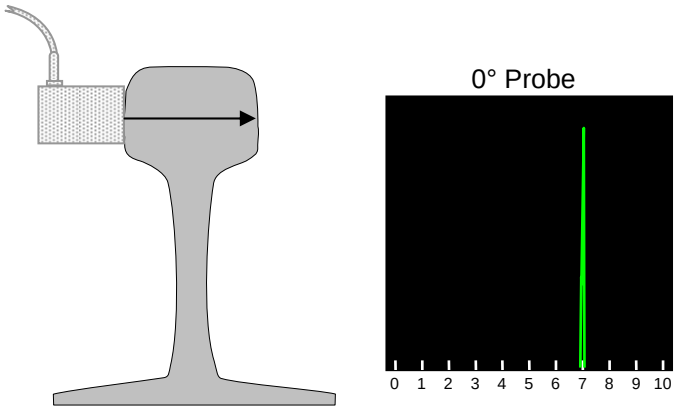

Figure 29 – Signal from opposite side of head

3. Place probe on outer extremity of foot with probe overhanging the edge of the foot
4. Set reflection from base of foot on ‘1’ on base line of screen (the extremity of the foot is 10mm thick at the edge)

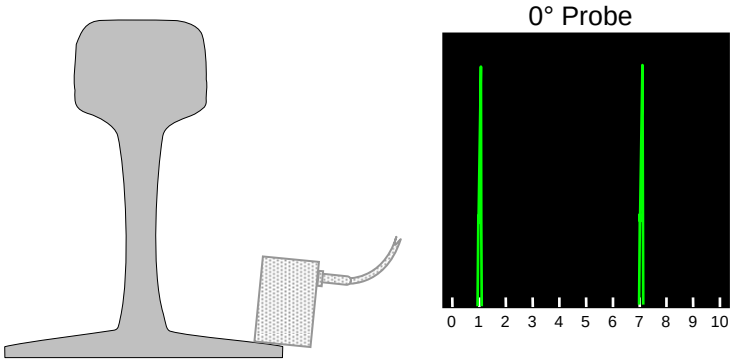

Figure 30 - Signal from edge of foot

5. Repeat Steps 2 and 4 until both signals are set in correct position.
6. Note: Screen is now set to read depth of horizontal indicators in mm.
7. Place probe on top of head and size indicators for both depth and length.

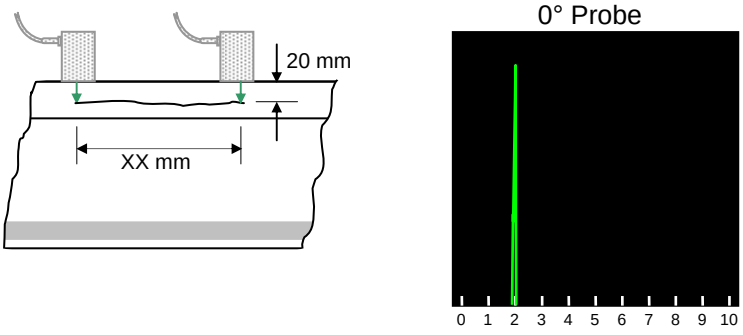

Figure 31 – Measuring depth and length of indications

C8-6.1 Scanning for wire feed weld defects with a twin 0° probe

1. Move the probe in a longitudinal direction along the rail keeping the probe centred over the web.

   Test the repair area plus 100mm each side, paying particular attention to weld depth area (i.e. weld/rail interface).

   Horizontal defects in a wire feed weld will appear between 0 and 2 on the base line of the screen (the head area of the rail) when using a '0 probe'.

Guidance Notes
1. It is useful to place the '0 probe' down on the very extremity of the foot prior to testing for wire feed defects as this will show the operator where at the zero end of the screen a lamination of 10mm depth will appear on the base line. It also assists in setting the gain for looking at shallow indications.

Variations from the standard signal presentation on the flaw detector screen should be investigated using the Sizing Procedure in Chapter 10 to determine whether they qualify as a defect.

C8-6.2 Back Wall Echo (BWE)

When testing from the top of the head on standard rail which is **not** defective, there should be a strong back wall echo from the base of the rail set between 9 & 10 on the screen. Loss of this back wall echo can indicate the presence of a defect.

Other rail features can however effect this signal.

Loss of back wall echo when the rail is not defective can be the result of:

1. When a railhead is worn so that the probe is tilted toward the field side top fillet.

   This will result in a loss of back wall but stronger echo's from the top fillet and base of the head. These signals typically display on 2 and 3½ on the base line of the screen.

2. When testing the nose of a crossing or curve worn rail where the centre of the head is no longer over the centre of the web due to machining or head wear.

   This prevents the beam getting to the base of the rail.

3. Surface damage to the head including sub-surface laminations or grooving of the head due to wear, particularly on the nose or wing rail of a crossing.

4. Probe surface not making proper contact with the surface of the rail. eg. grease, poor probe surface, insufficient coupling (water). These problems should be corrected.

Other, less common, faults in rail can cause loss of Back Wall Echo. These include:

1. Loss of back wall echo from the base of the foot with an twin 0° probe can also be caused by loss of section in the web due to corrosion. This usually occurs in tunnels or other damp areas and is rare in other locations. If the corrosion reduces the internal width of the web then it can stop the beam from reaching the base of the foot. Major corrosion can be seen by visual examination and may warrant removal of the rail. Corrosion is also the most common cause of Foot/Web Separation (FWS)

2. Another occasional cause for this signal loss can be lamination just beneath the top surface of the head. This sub-surface lamination can be due to shelling or lamination from engine burns or where squats are occurring.

   Shallow indications due to the above will display at the zero end of the screen.

C8-7 Using a miniature 0° probe for locating VSH defects

C8-7.1 Setting up procedure

1. Use the appropriate miniature 0° probe. (4NF/MB4F).
2. Place the probe on the vertical face of the head on the field side of a new rail.
3. Set the left-hand side of the transmission signal on Zero along the base line of the screen and the left-hand side of the signal from the opposite side of the head (back wall echo) on 10. If preferred, the back wall echo can be set on 5 and the repeat of the back wall echo on 10. Set the Gain initially to 58db.

C8-7.2 Scanning for VSH defects

1. Conduct two (2) Lengthwise Testing Passes along the Vertical Face of the Head on the Field Side of the rail ensuring that the 'grass' is at 1/5th screen height for both passes. Adjust the Gain when required to maintain this level of 'grass'.

Pass 1 is conducted adjacent to the base of the head to check for inclusion bands (IB's). Keep the edge of the probe in line with the bottom comer of the rail head.

Pass 2 is conducted adjacent to the top of the head to check for a potential VSH. Keep the edge of the probe in line with the top corner of the rail head.

Guidance Notes

1. If the rail is badly curve worn an intermittent back wall echo may occur around '5' along the base line of the screen and a signal from an IB or VSH may be dose to this signal eg on '4'.

2. If there is a significant angular chamfer at the top of the head on the field side then the base of the chamfer should be treated as the top of the head for the testing pass adjacent to the top of the head. If there is a lip at the top of the rail head then a pass immediately beneath the lip should be regarded as the pass adjacent to the top of the head.

2. To qualify as a valid indication the reflection must appear as a continuous signal on the screen between '1' and the back wall echo signal on the base line and be of full screen height.

   If however the testing surface is poor due to rough texture or irregular angles then an indication of only 70% screen height is required.

3. If a valid indication is present in the testing window then it should be sized using the Sizing Procedure in Section C10-10 to determine if a defect is present in the rail.

   If an indication of full screen height is found on both the top and bottom passes at the same location in the head, then the top indication only should be sized.

Chapter 9 Calibration

C9-1 Calibration and function test of flaw detectors

C9-1.1 Daily Calibration assessment and function test

At the beginning of each day before doing any kind of testing use the VS70 probe with the VS70 setting up block to check the flaw detector for proper function and calibration.

Also ensure the 'Grass' is 1/5th screen height in the testing window when testing with any probe.

C9-1.1.1 Calibration of USK7/S Rail Flaw detector units

Test Block. (Required for calibrating the screen)

Use a piece of rail flange 80mm long with a saw cut end. Engrave two permanent transverse lines at 30mm and 50mm, parallel to the saw cut end.

Note: This setting up procedure has been established using the RIS modified VS70 probe. The wear shoe on the RIS modified probe adds an additional 3mm to the front of the probe. If a probe without a wear shoe is used, you need to make adjustments to the setting.

Setting Up Procedure

The Calibration method for testing the foot of aluminothermic field welds using a VS70 probe involves setting up the screen to indicate the measurement or distance from the front of the probe to any interface encountered by the beam. (See Figure 33).

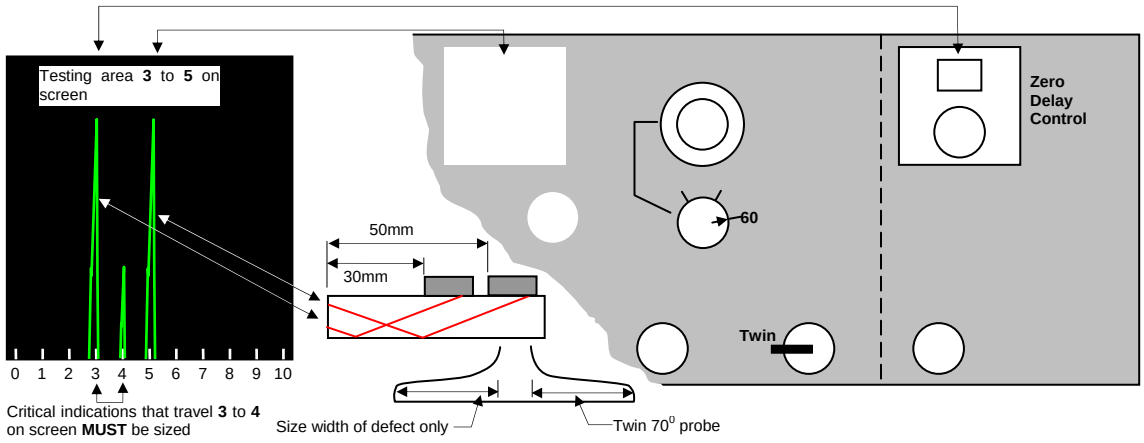
Testing area 3 to 5 on screen
0 1 2 3 4 5 6 7 8 9 10
Critical indications that travel 3 to 4 on screen MUST be sized
50mm
30mm
Size width of defect only
Twin 70⁰ probe
60
Twin
Zero Delay Control

Figure 32 – Setting up procedure for twin 70^0 probe

Use the 20mm 'web side' edge of the block for this setting up procedure.

4. Connect the VS70 Probe to the flaw detector.
5. Switch on the flaw detector and set to twin probe operation.

Calibrate the Screen

1. Place the probe on the test block and line up the front of the probe with the 30mm mark.

   (Note: Set **Gain Control** to a 'Grass' level of 1/5 screen height).
2. Adjust the reflected signal from the end of the block to number '3' on the base line of the screen with the Pulse Delay Control. (Note: Always use the left-hand side of the signal).
3. Move the probe back until the front of the probe is exactly in line with the 50mm mark on the test block.
4. Adjust the reflected signal from the end of the block to number '5' on the base line of the screen with the Test Range Control.
5. Repeat Steps (3) and (4) 6 as many times as necessary until both the signals at 30mm and

50mm from the end of the block are in exactly the correct positions on the screen i.e. '3' and '5' respectively.

When carrying out the above steps it is essential to visually follow the signal on the screen as it travels from 3 to 5, to ensure that the same signal is being used for setting up.

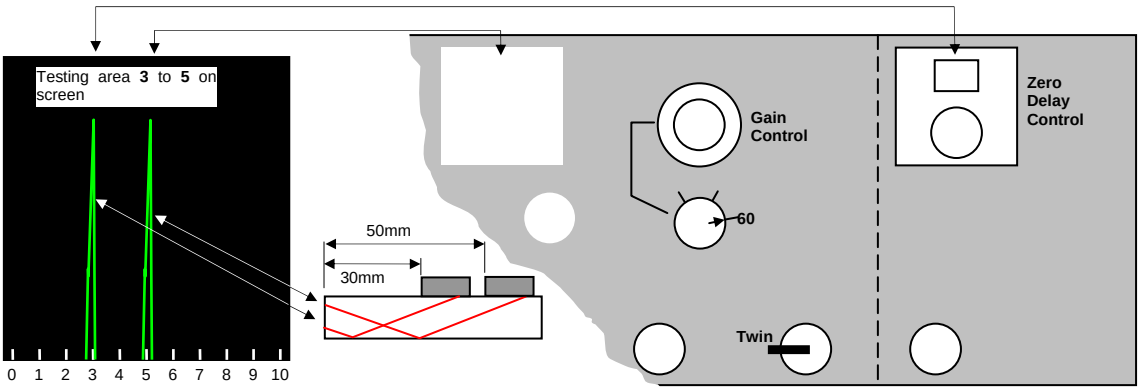

Figure 33

C9-1.1.2 Calibration of USM25/USM35 units

1. Recall the VS70 memory preset
2. Check that the signal locations at 3 & 5 on the base line of the screen, correspond with the graduations at 30 and 50 mm on the test block.

C9-1.2 Annual calibration assessment and function test

All Flaw Detectors are to be checked for calibration and proper function for the testing of rail every 12 months by Rail Inspection Services using the method described in AS 2083. If further assessment or adjustments are required the unit must be forwarded to the Supplier/Manufacturer for a more comprehensive assessment and adjustment.

C9-2 Establishing Zero for probes

Use the following procedures to set the probe delay on the screen to establish zero for each individual probe.

C9-2.1 Zero Delay for 70° and 38° probes

C9-2.1.1 USK7/S Units

The delay established when setting up with the VS70 Probe and test block in Section C9-1.1.1 above is suitable for the other standard probe tests when using analog type flaw detectors.

Lock the Zero Delay Control after setting up and use the same setting for all angle probes.

C9-2.1.2 USM Units

Use the following method to set zero on individual screens (test settings to be stored in memory) when using digital units such as the USM 25 or 35:

1. Select Range Control(menu)
   - ~ Set the depth for the test. (See relevant setting up steps)
2. Select Probe Delay (menu)
   - ~ Place the angle probe on the VS70 test block facing the transverse end
   - ~ Move the probe forward until the beam centre of the probe is in line with the end of the block.
   - ~ Use the Probe Delay Adjustment to set left-hand side the signal from the end of the block on zero.

3. Select Range Control.
   - ~ Re-check depth after the probe delay is set
   - ~ Re-adjust range control if required.

C9-2.2 Zero Delay for Twin 0° probe

C9-2.2.1 USK7/S Units

The zero delay established when 'setting up' with the VS70 Probe on the test block (see Section C9-1.1.1) is suitable for the Twin Zero Probe.

Alternative method

1. Use the Range Control to set the depth for the test. (See relevant setting up steps)
2. Use the Zero Delay Control to set the reflected signal from the base of the probe on zero.
3. Use the Range Control to re-check depth setting after the probe delay is set. Re-adjust range control if required.

C9-2.2.2 USM Units

Use the following method to set zero on individual screens (test settings to be stored in memory) when using digital units such as the USM 25 or 35:

1. Select Range Control(menu)
   - ~ Set the depth for the test with this control.
2. Select Probe Delay (menu)
   - ~ Set the reflected signal from the base of the probe on zero.
3. Select Range Control.
   - ~ Re-check depth setting after the probe delay is set
   - ~ Re-adjust range control if required.

C9-2.3 Zero Delay for Single 0° probes (K4NF)

C9-2.3.1 USK7/S Units

1. Range Control
   - ~ Set the depth for the test. (See relevant setting up steps)
2. Zero Delay Control
   - ~ Adjust the left-hand side of the transmission signal from the probe to zero on the base line of the screen.
   - ~ Re-check depth setting and adjust as needed with the Range Control.

C9-2.3.2 USM Units

Use the following method to set zero on individual screens (test settings to be stored in memory) when using digital units such as the USM 25 or 35:

1. Select Range Control(menu)
   - ~ Set the depth for the test with this Control.
2. Select Probe Delay (menu)
   - ~ Set the left-hand side of the transmission signal from the probe on zero.
3. Select Range Control(menu)
   - ~ Re-check depth setting after the probe delay is set
   - ~ Re-adjust range control if required.

Chapter 10 Ultrasonic Sizing Procedures

C10-1 Select sizing method

Sizing is undertaken after ultrasonic scanning for defects finds indications that meet or exceed the threshold levels described in Chapter 8.

When a potential defect indication in rail is to be sized, two criteria need to be decided before sizing is commenced. The first is the gain level for sizing and, based on this, the method of sizing to be employed.

Two methods are used to establish defect size, depending on the type of defect and probe. The methods are:

1. Sizing defects with gain at normal scanning level.
2. Sizing defects with the defect signal adjusted to the top of the screen (last significant echo method using 6db drop to define defect extremities). There are two approaches to this method. See last significant echo method, Approach 1 step 2, for most suitable approach).

Conduct the following sizing procedures using the Normal Scanning Gain sizing method detailed in Section C10-3.

1. **ALL sideways** sizing with the **WB70** and **VS70** probes.
2. **ALL** sizing with the **SEB0** probe.
3. **ALL** sizing of **Horizontal Splits**, even with the **WB35** probe.
4. **ALL** sizing of **Vertical Splits**.
5. **ALL** sizing of **Large Bolthole cracks** with a **WB35** probe.
6. **ALL** sizing of **Gassing Defects** in **aluminothemic welds** with **WB70** and **WB35** probes.
7. Sizing of **Gassing Defect** in **aluminothemic welds** using loss of back wall echo with an **SEB0** probe.
8. **ALL** sizing of in **the foot defects** in **aluminothemic welds** with a **WB35** probe.
9. Sizing of **aluminothemic weld defects** associated with an unusually high 'grass' level.

Use the Last significant Echo method detailed in Section C10-4 and C10-5 when carrying out **longitudinal** (lengthways) sizing with the **WB70** or the **WB35** probe when determining the size the following types of defects:

1. All **longitudinal** (lengthways) sizing of **aluminothemic** and **flash butt weld defects** (except thermit gassing defects or welds with defects associated with an unusually high 'grass' ratio) with the **WB70** and **WB35** probes.
2. All **longitudinal** sizing of **Transverse** defects (TDs) in the **rail head**, including defects due to Shelling and Engine Burns with the **WB70** and **WB35** probes.
3. All **longitudinal** sizing of **Small Bolthole** defects with the **WB70** and **WB35** probes.

C10-2 Scanning gain defined

All testing for the location of defects should be conducted with a Gain setting that provides a 'grass' of 1/5th screen height (Scanning Gain). This is the normal testing level for this application.

'Grass' refers to the display along the base line of the screen when a probe is moved over the material being tested. This display is the reflected energy from the grain structure of the material, its height on the display being determined by the level of gain.

The base line 'grass' should not exceed 1/5th screen height when sizing rail or rail weld defects. If this gain level does not produce an indication that reaches the top of the screen then the indication should be disregarded unless it is established as a defect with another probe.

C10-3 Normal Scanning Gain sizing method

1. Peak the defect signal. Move the probe forward towards the defect and then backwards away from the weld until the highest possible signal is obtained from the defect. Use the full width of the rail head when peaking the signal.
2. Leave the gain at normal scanning level. DO NOT reduce the gain to size.
3. Move the probe backward until the last significant signal from the extremity of the defect drops to ½ screen height. Mark the side of the rail with chalk in line with the beam centre of the probe.
4. Peak the defect signal again as in step (1). This allows the operator to re-establish the defect position.
5. Repeat step (3) in the forward direction.
6. The distance between the two chalk marks represents the total movement of the probe.
7. Determine the size classification of the defect based on longitudinal probe movement by reference to the sizing chart in Section C10-13.

C10-4 Last significant echo method - Approach 1

The sizing procedure is based on the 'last significant echo' sizing method detailed in Australian Standard AS 2207.

For the practical purpose of clearly defining the marking point for the probe, a 6db loss in the maximised height of the defect signal is used to define the point of rapid drop.

1. Turn down the scanning gain used when scanning for defects prior to sizing so that the best signal from the defect just reaches the top of the screen.
2. Add 6db to the gain.

   Note 1: If the grass level reaches ½ screen height use the 'Last significant echo method - Approach 2' detailed in Section C10-5.

   Note 2: Remember that for all gassing type defects use the 'Normal Scanning Gain' method of sizing detailed in Section C10-3.
3. Move the probe until the last indication from each extremity of the defect drops to full screen height on the display.
4. Mark the rail at the beam centre of the probe.

Note: Always remember to adjust the gain back up to normal testing level before doing sideways sizing with a 70° probe and before resuming to scan for defects.

C10-5 Last significant echo method - Approach 2

1. Peak the defect signal. Move the probe forward towards the defect and then backwards, away from the defect until the highest possible signal is obtained from the defect. Use the full width of the rail head when peaking the signal.
2. Adjust the gain until the peaked signal just reaches the top of the screen.
3. Move the probe backward until the last significant signal from the extremity of the defect drops to ½ screen height. Mark the side of the rail with chalk in line with the beam centre of the probe.
4. Peak the defect signal again as in Step (1). This allows the operator to re-establish the defect position.
5. Repeat Step (3) in the forward direction.
6. The distance between the two chalk marks represents the total movement of the probe.
7. Determine the size classification of the defect based on longitudinal probe movement by reference to the sizing chart in Section C10-13.

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C10-6 Sizing of head defects in rail welds and TDs with a 70° probe

Two sizing procedures should be used for the rail head. They are longitudinal and sideways sizing procedures.

C10-6.1 Longitudinal sizing procedure

Longitudinal sizing is always done in both testing directions to determine the initial size classification before commencing sideways sizing.

1. **Peak the defect signal**. Move the probe forward towards the weld and then backwards away from the weld until the highest possible signal is obtained from the defect. Use the full width of the rail head when peaking the signal.
2. Adjust the gain until the peaked signal just reaches the top of the screen then add 6db to the gain.

   Note 1: If the grass level reaches ½ screen height use the 'Last significant echo method - Approach 2' detailed in Section C10-5.

   Note 2: Remember that for all gassing type defects use the 'Normal Scanning Gain' method of sizing detailed in Section C10-3.
3. Move the probe backward until the last significant signal from the extremity of the defect drops to full screen height. Mark the side of the rail with chalk in line with the beam centre of the probe.

   NB. Use full width of rail head when sizing and ensure signal from the defect has dropped to full screen height for the last time.
4. Peak the defect signal again as in Step (1). This allows the operator to re-establish the defect position.
5. Repeat Step (3) in the forward direction.
6. The distance between the two chalk marks represents the total movement of the probe.
7. Determine the size classification of the defect based on longitudinal probe movement by reference to the sizing chart in Section C10-13.

C10-6.2 Sideways sizing procedure

Sideways sizing should also be done from both testing approaches to the weld.

1. Return gain to normal testing level ie. 'Grass' should be 1/5th screen height.
2. Move the probe back and forth over the defect to obtain the best possible reflection from the defect. DO NOT turn the gain down.
3. Move the probe sideways keeping it parallel with the edge of the rail until defect signal drops to ½ screen height at the extremity of the defect. Mark the rail head at the front centre of the probe.
4. Return probe to original position by moving sideways until the best defect signal is again obtained.
5. Repeat Step (3) in the opposite adjacent direction without lifting the probe off the rail.
6. Note whether the sideways movement (ie. distance between marks) is equal to ½ way, ¾ way or full width across the rail head.
7. Refer to the Sizing Chart in Section C10-13 to determine the adjusted Size Classification if indicated.

C10-7 Sizing of web and flange defects in rail welds and rail with a 38° probe

1. **Peak the defect signal**. Move the probe backwards and forwards until the highest possible signal is obtained from the defect. Remember, the 38° probe must at all times be kept directly over the centre of the web.
2. Adjust the gain until the peaked signal just reaches the top of the screen then add 6db to the gain.

Note 1: If the grass level reaches ½ screen height use the 'Last significant echo method - Approach 2' detailed in Section C10-5.

Note 2: Remember that for all gassing type defects use the 'Normal Scanning Gain' method of sizing detailed in Section C10-3.

3. Move the probe backward until the last significant signal from the extremity of the defect drops to full screen height. Mark the side of the rail with chalk in line with the beam centre of the probe.
4. Peak the defect signal again as in Step (1). This allows the operator to re-establish the defect position.
5. Repeat step (3) in the forward direction.
6. The distance between the two chalk marks represents the total movement of the probe.
7. Determine the size classification of the defect based on longitudinal probe movement by reference to the sizing chart in Section C10-13.

C10-7.1 Sizing information relating to the 70° and/or 38° probe.

1. Carry out the sizing procedure in both testing directions to determine the greatest probe movement. Use the longer of the two probe movements to determine the size of the defect.
2. When sizing head defects which have more than one reflective face, always use the face with the lowest energy return as the indication for peaking prior to sizing.
3. When using a 38° probe any indication found in welds, which has qualified by probe movement as a defect and occurs between 8 and 10 on the base line of the screen is a Flange Defect and should be classified as Medium ie. DW-M. If the probe movement shows a large defect to be present then a DW-L classification would apply.
4. The base line 'grass' scanning gain as defined above should not significantly exceed 1/5th Screen Height, when sizing rail or rail weld defects. If this gain level does not produce an indication that reaches the top of the screen then the indication should be disregarded unless it is established as a defect with another probe.
5. If welds or rail cannot be properly tested due to poor surface condition or lack of access, report them as defects so that corrective action can be assessed.

C10-8 Sizing of flange defects in rail welds with a miniature twin 70° probe

When sizing defects in the foot of the rail with a VS70 probe the size of **any defect found is determined by its width only** and is assessed by moving the probe sideways to determine the two transverse extremities of the defective area.

1. The best possible reflection from the defect should be obtained by the longitudinal passes, and usually occurs between ‘3’ and ‘5’ on the base line of the screen. The front of the probe should be kept at this distance from the weld to facilitate sizing. (The gain should be left at normal testing level i.e. the ‘Grass’ should be 1/5th screen height within the above indicated testing window).
2. Move the probe sideways toward the edge of the flange until the defect signal drops to ½ screen height.
3. The rail should then be marked at the front centre of the probe.
4. Move the probe sideways toward the web until the defect signal once again drops to ½ screen height and mark the rail as in step three.
5. Measure the distance between the two sizing marks and refer to the sizing code (attached) for the correct classification.

Notes:

When sizing, always ensure that the defect indication has dropped to ½ screen height for the last time before marking the rail at the front centre of the probe.

Ensure that the flange surface remains saturated with water and that sufficient ‘grass’ can be seen on the screen at all times when testing and sizing defects.

Special care is needed to detect defects extending from under the edge of the web outwards underneath the bottom fillet radius. A defect indication may be at full screen height when the edge of the probe begins to lift off the surface due to the lower fillet radius. If any indication displays strongly on the screen in the testing window as displayed in Figure 24 but drops due to the probe lifting off on the radius the weld should be classified as a DW-M Foot. The indication should however be classified as a DW-L if this is warranted by the probe movement.

C10-9 Sizing Defects with a Twin 0° Probe (SEB-2 0).

Size horizontal indications using the 'Normal Scanning Gain' method of sizing as outlined in Section C10-3. When sizing zero probe defects, always maintain the gain at normal scanning level (20% grass).

C10-10 Sizing of VSH defects with a miniature 0° probe

This sizing is carried out lengthwise along the side of the head with the edge of the probe in line with top of the head. All sizing should be conducted at normal testing level ie 'grass' at 1/5th screen height.

The length of the defect should be determined by marking the rail at the centre point of the probe when the indication has dropped to 50% screen height for the last time at the two testing extremities of the defect. The distance between these marks at the two sizing extremities should be measured.

If a probe movement of 50 mm in length or more is obtained then the rail should be removed as a VSH-S. For larger defects refer to the defect limits in Section C4-6.

If the space between separate defects is less that 100mm then the defects should be treated as one continuous defect. If the space between defects is 100mm or more then the defects should be regarded as separate defects.

Note: For the purpose of removal where there are multiple defects in a rail then the two extremities of a group of defects should be clearly marked on the rail.

C10-11 Sizing of wire feed defects

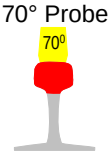
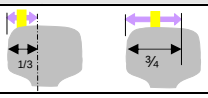
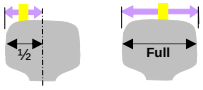
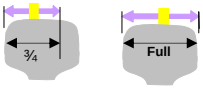
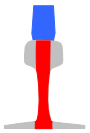
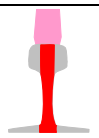
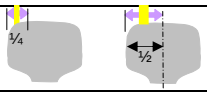
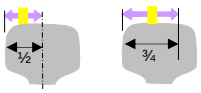
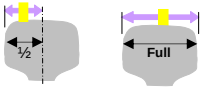
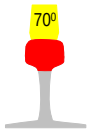
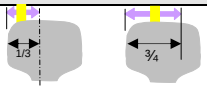
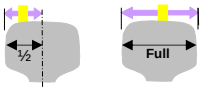
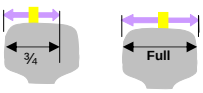
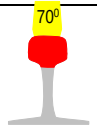
Removal criteria for a horizontal indication with a 0° probe is 25 mm probe movement in any sizing direction. Removal criteria for a transverse indicator with a 70° probe is 25mm longitudinal probe movement with a sideways width of ¼ rail head width. See Sizing Code Section C10-13.

C10-12 Sizing of Horizontal Split Head [HSH] defects

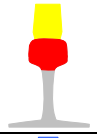
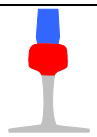
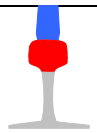
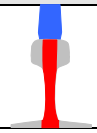
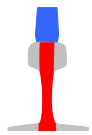
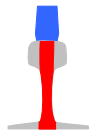
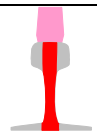
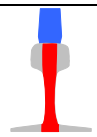
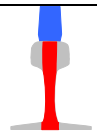
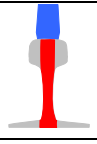
A Horizontal Split Head [HSH] defect is any horizontal crack in the head which is 10mm or greater in depth and meets the standard sizing criteria (longitudinal probe movement). Horizontal indications which are associated with squat lamination or rolling contact fatigue cracking should not be classified as a HSH unless the lamination is 10mm in depth or greater.

When shallow horizontal laminations associated with squats or rolling contact fatigue are present in the rail, determine remedial action on the basis of the severity of surface damage. Refer to Table 3 in Section C4-4.2 to determine remedial action when rail containing the above types of shallow sub surface lamination is detected.

C10-13 Classification of rail defects by probe movement (Sizing Chart)

Classification of rail defects by probe movement for K.K Operators					
Probe	**Type of Defect**	**Code**		**Probe Movements for Size Definition**	
		Type	**Size**	**Longitudinal**	**Sideways**
Defective Welds				**If this**	**AND this**
70° Probe 	Head	DW	S	40mm to 56mm	
			M	57mm to 90mm	
			L	over 90mm	
0° Probe 	Full Weld Gassing Defects	DW Gassing	M	Loss of weld base signal over 35mm or width of weld	
	All Horizontal Web Defects	HSW HWS FWS	M	15 to 75mm	
			L	75 to 150 mm	
			E	over 150 mm	
	Web/Centre Foot Sectional Defects	DW	S	25 to 50mm	
			M	51 to 75mm	
			L	over 75mm	
Twin 70" Probe	Foot Defect Width *Note: The foot test is for aluminothermic welds only*	DW	M		15 to 35mm or 10 to 35mm if indication starts from outer edge of foot
			L		Over 35mm
70° Probe	Wire Feed Welds & New Flash Butt Welds *Conduct 0º Probe test for laminations in wire feed welds.* *Use probe movements as for 70º Probe for defect assessment and classification.*	DWFW	S	25mm to 56 mm	
			M	57mm to 70mm	
			L	over 70 mm	
Head defect in plain rail					
	Transverse Defects in rail head Transverse fissures Transverse shelling Shatter cracks	TD	S	40mm to 56mm	
			M	57mm to 90mm	
			L	Over 90mm	
	Engine Burn Fracture	TD/EBF	S M L	Same as TD Size as TDM if complete reading is not possible.	Same as for TD

Classification of rail defects by probe movement for K.K Operators

Probe	Type of Defect	Code		Probe Movements for Size Definition	
		Type	Size	Longitudinal	Sideways
	Multiple Transverse Head Defects	TDX	S M L	Same as TD	Same as for TD
	Horizontal Split Head Applies to horizontal indications with a depth of 10mm or more. For rail with surface damage and shallow lamination- see C4-5.2 for remedial actions.	HSH	S M L	25 to 100mm 101 to 200mm over 200mm	
	Vertical Split Head *Use next size up when* – *defect has visible cracking or discoloration , OR* – *defect is within 100mm of Weld, Joint, BH and has a significant dip in rail, OR* – *if tangent wear ≥ 10mm.* *Refer to Chapter 11 and C10-10 for more details*	VSH	IB S M L E	<50 long <15 from top OR >50 long >15 from top 50-200 long <15 from top 201-400 long <15 from top >400 long <15 from top >400 long with visible cracking or head dip >0.5mm or defect > 1metre long.	*If distance between adjacent VSH is < 100mm treat as one defect.* *If > 100mm then treat as separate defects.*
Web and foot defects in plain rail					
	Head and Web Separation *Use weld sizing sheet Horizontal Defects if defect is at a weld or rail end.*	HW	S M L	20 to 75mm 76 to 200mm over 200mm	
	Foot and Web Separation	FW	S M L E	20 to 40mm 41 to 75mm 75 to 150 mm over 150 mm	
	Horizontal Split Web	HSW	S M L E	20 to 40mm 41 to 75mm 75 to 150 mm over 150 mm	
	Bolthole Crack All angles	BH	S M L	20 to 40mm 41 to 75mm over 75mm	
	Vertical Split Web Longitudinal	VSW	S	Any reading in one rail length	
	Piped Rail	PR	S M L	25 to 150mm 151 to 300mm over 300mm	
	Transverse Split Web	TSW	S M L	20 to 40mm 41 to 75mm 75 to 150 mm	
	Mechanical Joint Suspect	MJS	*When you are unable to test the rail end of a mechanical joint due to damaged rail ends, defective weld build up or incorrectly drilled boltholes, the joint should be marked out and reported as an MJS.*		

Chapter 11 Assessment of VSH Rail Defects

When a Vertical Split Head rail defect is found in track, it is necessary to determine if it is safe to allow traffic to pass for a short period until repairs can be undertaken. The following guidelines will assist staff with the assessment of VSH rail defects and the determination of operating restrictions that are to apply.

C11-1 Rail Testing

If the defect has been found by other than manual ultrasonic testing (eg Track Patrol or Rail Flaw Detection Car), arrange for the defect to be tested by manual ultrasonic testing.

Manual ultrasonic testing involves checking the length of defect and checking that no other types of crack have initiated in any included welds (such as a horizontal crack or transverse defect).

C11-2 Assessment

All VSH large defects should be removed as soon as possible. The maximum periods given are only applicable where larger numbers of defects have been found than can be dealt with quickly.

1. DO NOT plate the defect. Plating does not help and may cause additional problems.
2. Remove the defect if you have appropriate tools and equipment and sufficient time.

   Remove the full length of rail (normally 13.75m) if there are already thermit welds in the length. If this can't be done immediately install a closure to remove the defect and replace the full length within six months.

   DO NOT place any new aluminothermic welds within 500mm of a VSH defect.. As a temporary measure a weld can be installed but only for defects classified as IB and clear of the weld by at least 200mm. Remove these temporary welds within 30 days.

If you cannot remove the defect:

1. Check for visible cracking.
2. Check for disjoint across the crack faces if cracking is visible.

   A “disjoint” is where the crack faces overlap or have pulled apart.
3. Establish the location of the crack relative to the head, web, any welds or boltholes.
4. Check on both sides of the rail (especially in the head-web fillet area) to see if the crack is visible.
5. Measure the length of the crack.
6. Measure the dip in the rail surface to the nearest 0.1mm using a taper gauge or feeler gauge at the centre of a 1m straight edge placed along the rail. The centre of the defect should be checked along with any locations where there is visible widening of the contact band.
7. Check for a discolouration band.

   This is the band that may be found under the rail head in the web fillet (sometimes called a “rust band").
8. Use the results of the ultrasonic test and your visual inspection and measurement to determine appropriate speed and monitoring conditions to apply. Follow the guidelines in Table 10.

   ~ SELECT the appropriate speed response for the defect. (There is no need to continue the assessment once a STOP TRAINS response has been established).

   ~ When the assessment is finished, the LOWEST speed selected for ANY answer is the speed restriction that can be applied.

Defect Indication or size	Action
Visible crack with disjoint across crack faces	**Stop Trains**
Visible crack which has turned up into the head or turned down into the web (including down into a weld) or any crack running into a *bolthole*	
Visible crack on both sides of the rail	
Visible crack greater than 1m in length	
Dip greater than 3.5mm	
Any visible crack	**Priority 1** 20/10kph Monitor Remove urgently
Dip greater than 1.2mm and up to 3.5mm	
Where a VSH crack has changed into another type of defect at a weld (such as a horizontal crack or transverse defect)	
Discoloration band	**Priority 2** 40/20kph Remove defect within 48hrs Visually reassess every 12hrs Test ultrasonically every 24hrs
Internal defect passes within 100mm of a weld or *bolthole*	
Internal defect is continuous greater than 1m (continuous including where less than 200mm between continuous internal cracks)	
Dip is greater than 0.5mm up to 1.1mm	
Defects not meeting any of the above criteria	Classify defect as Large, Medium or Small in accordance with sizing criteria in Section C4-6.

Table 10 - Vertical Split Head Assessment Guidelines

C11-3 Recording and reporting VSH defects

1. Complete a Rail Fail Form RF1 (see Appendix 1) using the guidelines in Chapter 13 and the additional information in Step (1) below for each VSH defect.
2. Record the following additional information on the form:

   ~ If the gap between two or more defects is less than 100mm classify the defects as one continuous defect.

   Detection

   ~ If found by Manual Ultrasonic testing from non-routine testing, circle “Special Manual Ultrasonic Test”.

   ~ If found as a result of Rail Cleanliness Testing, circle “Rail Cleanliness Testing”.

   Rail Cleanliness Testing is special testing to look for rail inclusions and very small defects in the rail.

   ~ Use the space in the item to record the name and position of the person who has classified the defect.

   Defect type

   ~ If more than one defect has been found in the one rail length (between flashbutt welds) write in the number of additional defects after “Other” in the form “xx additional defects.”

   Rail section

   ~ Measure the head height (as for tangent wear) and write the measurement after “Other”.
3. Send completed Rail Fail forms for VSH defects by fax to Rail Inspection Services within 2 working days of the detection of a VSH defect.

   If there is any delay in completing the form fax in an interim form as soon as possible with the word “INTERIM” written at the top of the form.

Chapter 12 Assessment of Broken Rails

When a broken rail has been found in track, it is sometimes necessary to determine if it is safe to allow traffic to pass for a short period until repairs can be undertaken.

Warning:
The ends formed by a broken rail may be subject to electrical arcing. Track staff should consult with signal staff on what, if any, precautions to apply and the bonding required

The following guidelines will assist staff with the assessment of broken rails and the determination of operating restrictions that are to apply. They should only be used as a temporary measure to defer full repair until a suitable break in traffic is available or to avoid a peak period.

C12-1 Definitions

Track Assessor:	a person who is competent in the competency “TLIB3099A - Examine track infrastructure "
Monitor:	Visually assess gap and check and retighten clamps

C12-2 Assessment

If you are on site;

1. Examine the condition of the broken rail
2. Repair the broken rail if you have appropriate tools and equipment and sufficient time. If NOT…….
3. Plate the broken rail if you have appropriate tools and equipment and sufficient time. If you can plate the broken rail, use the guidelines in Table 12 to determine appropriate speed and monitoring conditions to apply
   - ~ Ideal conditions are a single break, clear of joint or weld with a gap less than 30mm, and if on the high rail, a curve more than 500m radius, and with good track support.
   - ~ Reduce the speed for less than ideal conditions.
   - ~ For gaps >30mm apply the restrictions relating specifically to rail gap from Table 11, even if the broken rail is plated. If the break is plated, no allowance needs to be made for opening under load.
4. Arrange for monitoring of plated broken rails at a frequency that matches the condition of the break and the type and frequency of rail traffic.
5. Carefully assess the effectiveness of plating for break types that are not clean and square. In some cases there would be no reduction in risk and the only option will be to replace the rail with a closure. In other situations there may be a limited improvement sufficient to allow limited rail operations until the broken section can be replaced.
6. If you cannot remove or plate the broken rail, you MUST follow the guidelines in Table 11
   - ~ Answer ALL of the questions in Table 11.
   - ~ SELECT the appropriate speed response for EACH answer. (There is no need to continue answering questions once a STOP TRAINS response has been established).

     The best case is where the track is straight and well supported and restrained considering the operating loads.

     Assess the potential increase in rail gap under a train and add it to the static gap measured before determining the response required. For elastic fastenings the increase should be 5mm for passenger trains, 10mm for freight trains. For non-elastic fastenings 10mm for passenger trains and 15mm for freight trains. These values can be adjusted by observing actual trains in service. For constrained situations such as within a crossing or turnout, no allowance need be made.
   - ~ When ALL questions have been answered, the LOWEST speed selected for ANY answer

is the speed restriction that can be applied.

~ The maximum possible speed from Table 11 is 40km/hr.

7. If you cannot get to site and you can establish two-way communication with lesser qualified staff on-site, you may be carry out a remote assessment. For this to work your communication needs to be sufficient to determine:
   ~ the size of the gap,
   ~ whether the break is clean and square and with the gauge face of the ends aligned, and
   ~ whether the track is in reasonable condition (not obviously boggy or distressed).
8. You will also need to know the curvature of the track and the type of traffic that runs over it (this can be from local knowledge).
9. Use the information you have from the person on-site to answer the questions in Table 11. Because you are not on-site to make a detailed assessment yourself, the following additional restrictions apply:
   ~ The maximum permissible track speed is 10kph, even if Table 11 indicates it could be higher
   ~ If the track break is not clean and square or there is any doubt about the condition of the break or track support, do not let trains travel across the break.
   ~ The person must remain on-site and monitor the situation as directed by you until you arrive.
   ~ You must inspect the site as soon as possible.
10. Monitor ALL broken rails that are unplated continuously, at least for the passage of each train. You can do this from a safe position away from the track provided you can observe the behavior of the track.
11. Re-measure the rail gap if it appears to have changed. If it has changed reassess the speed restriction.

C12-3 Repair of Broken Rails

Arrange for the broken rail to be repaired as soon as possible using the procedures in RailCorp Engineering Manual TMC 221.

– Plated broken rails that are not clean/square should be repaired or replaced within 5 hours.
– Plated clean square broken rails should be repaired or replaced within 8 hours.
– If the break cannot be repaired in that time its condition must be reassessed and additional monitoring should be arranged.

C12-4 Completing a Rail Fail form for broken rails

1. Complete a Rail Fail Form RF1 (See Appendix 1) using the guidelines in Chapter 13 as soon as possible after the broken rail has been plated or removed. Most of the information can only be obtained on-site.
2. Send completed Rail Fail Forms by fax/e-mail within 5 days of the rail break to:
   ~ Civil Maintenance Engineer
   ~ Chief Engineer Track
   ~ Rail Inspection Services

When the broken rail has been removed from track:

3. For simple breaks, cut two pieces of rail, one from each side of the break, each approximately 200mm long. For multiple breaks, collect all broken rail pieces.
4. Package the pieces of broken rail securely, with the details of the track, rail and kilometrage clearly marked on rail and with paperwork clearly identifying the incident (Copy of Telegram and Rail Fail form).
5. Deliver the package to Rail Inspection Services for analysis within 5 days of the break

ASSESSMENT OF UNPLATED BROKEN RAILS

*Answer **ALL** of the 13 questions below. **SELECT** the appropriate speed response for **EACH** answer. When **ALL** questions have been answered, (There is no need to continue answering questions once a **STOP TRAINS** response has been established) the **LOWEST** speed selected for **ANY** answer is the speed restriction to apply.*

	QUESTIONS	IF YES	STOP TRAINS	Check after each train	Speed (km/hr)				
					10	20	30	40	N/A
1	If the break is **NOT** a clean break is other cracking that could lead to additional pieces falling out (do not consider fine cracking on the rail head that is continuous along the rail)?	Trains may **NOT** pass unless a detailed assessment of cracking potential indicates further cracking will not lead to an unsafe situation. (**Maximum speed 10kph** and check cracking after each train)							
2	Are there any problems with the rail in the vicinity of the break? Including:- - any fine cracking visible on the top of the rail head running along the rail - wheelburns or rail dips - significant rail wear	**Maximum speed of 20kph** for any of the following: -fine cracks (with no spalling), minor wheelburns, minor rail dips, rail wear at reportable level. **Maximum speed of 10kph** for any of the following:- heavy cracks (with spalling), large wheelburns, large rail dips or rail wear at or near condemning level							
3	Is the break non-vertical (ie not square like a rail joint) and more than 30 degrees to the vertical?	Trains **SHOULD NOT** be permitted to pass unless a detailed assessment (of the crack slope, wheel impact, axle load, rail condition, track support condition) indicates the rail end will cope without collapse (**Maximum speed 10kph** and check after each train)							
4	Does the break pass through or within 50mm of a bolthole on the web of the rail?	Trains **SHOULD NOT** be permitted to pass unless a detailed assessment (of the crack slope, wheel impact, axle load, rail condition, track support condition) indicates the rail end will cope without collapse (**Maximum speed 10kph** and check after each train)							
5	Does the rail gap behave like a foul joint in one direction?	Trains **SHOULD NOT** be allowed to pass in that direction							
6	Is the track vertical or lateral support poor such that the track will flog or the rail subject to excessive bending or movement? This should include consideration of: the size of the rail, the sleeper spacing, the type and condition of the sleeper/fastening, the ballast condition	Reduce train speed appropriately. If too severe trains **SHOULD NOT** be allowed to pass							
7	Is the rail unrestrained (eg a switch)	Trains **SHOULD NOT** be allowed to pass							
8	Is the track subject to 30t axle load coal trains?	30t axle trains should only be allowed to pass if the track is in good condition and well supported and at a **maximum speed of 20kph**.							
9	Is the track poorly tied considering the curvature?	Assess condition, fastening and sleeper type and track curvature and apply speed restriction or stop trains (**0 to 20kph** depending on condition)							

ASSESSMENT OF UNPLATED BROKEN RAILS

*Answer **ALL** of the 13 questions below. **SELECT** the appropriate speed response for **EACH** answer. When **ALL** questions have been answered, (There is no need to continue answering questions once a **STOP TRAINS** response has been established) the **LOWEST** speed selected for **ANY** answer is the speed restriction to apply.*

	QUESTIONS		IF YES		STOP TRAINS	Check after each train	Speed (km/hr) 10	20	30	40	N/A
10	Is there a thermit weld or joint (not including a broken rail within the joint itself)?	≥ 1m but < 2m from the break **AND** with at least 2 good sleepers in between.	Assess the support condition of the intervening sleepers and fastenings and apply appropriate speed restriction	(**Maximum 20kph**).							
		≥ 0.5m but < 1m from the break **AND** with at least 1 good sleeper in between.		(**Maximum 10kph**).							
		within 0.5m of the break **OR** in the same sleeper bay	Trains **MAY NOT** pass								
11	Is the joint break at or beyond the back bolted bolthole (ie the furtherest from the joint gap)?		Trains **MAY NOT** pass								
12	Is the broken rail on the high rail of a curve with this radius and gap?	Radius / Gap	≤30	31-50	51-70	71-100	>100				
			Maximum speed								
		≥1000m	40	30	20	10*	Stop				
		700 - 999m	40	30	10*	Stop	Stop				
		500 - 699m	40	20	Stop	Stop	Stop				
		300 - 499m	30	10*	Stop	Stop	Stop				
		<300m	20	10*	Stop	Stop	Stop				
		* Check closely and remeasure after each train									

Table 11– Rails that have not been plated

ASSESSMENT OF PLATED BROKEN RAILS

Applies to gaps ≤30mm. For gaps >30mm apply restrictions for unplated broken rails

PLATING	RESTRICTION
Plated and held with G Clamps	**Maximum Speed of 30kph** under ideal conditions with monitoring after each train.
Plated and held with “Robel” Clamps	**Maximum Speed of 40kph** under ideal conditions with monitoring after each train.
Plated and held with “Robel” Clamps (if gap is less than 20mm)	**Maximum Speed of 60kph** under ideal conditions with monitoring after each train.
Plated with one bolt each side of gap	**Maximum Speed 40kph** under ideal conditions
Plated with at least two bolts each side of gap	**Maximum Speed 60kph** under ideal conditions

Table 12– Rails that have been plated

Chapter 13 A guide to completing a Rail Fail form

Complete a Rail Fail Form RF1 (See Appendix 1) as soon as possible after the rail defect or broken rail has been found. Most of the information can only be obtained on-site.

Person finding a rail defect or attending the broken rail	
Location	
Date of failure or date the failure was detected	There are six "boxes" in this section for recording data. The date of the failure is recorded in these boxes. For example, if the rail failed on 28 February 2005, the completed boxes would appear as: 2 8 0 2 0 5
Defect type	Are you reporting a rail defect or a broken rail? Put a 8 in the appropriate box
District	What District was it found on? Put a 8 in the appropriate box.
Kilometres	The location of the defect, recorded as kilometres to the nearest metre. eg 27.359
Base Code / Track	RailCorp has been divided up into small sections and each different section is given a different code number. Write down the line eg Bankstown, Illa Local, Suburban, Main North.
	The track on which the rail failed Circle the answer.
	Type of track. Main, Suburban, Refuge etc Circle the answer
Rail	The rail on which the failure occurred Circle the answer. UT = Up Turnout Rail, DT = Down Turnout Rail CP = Catchpoint *(Switch and Crossing is dealt with later)* Is it on High Rail or Low Rail or Tangent? Circle the answer.
Detection	
Method of finding defect	Circle the answer or write a response.
When found	*For Broken Rails only*. Write down what time the broken rail was found (use 24hr clock), who in the civil discipline it was reported to and what time it was reported.
Reported to	
When reported	
Defect or Break	
Position	Where on the rail was defect or broken rail found? Circle the answer. If it occurred in plain rail, write down measurements to the nearest metre.
Weld type	If the defect or break is at a weld, what type of weld is it? Circle the answer.
Age of Weld ***Area office to complete***	If the defect or break is at a weld, how old is it? Enter the answer in the boxes. For welds less than 1 year old enter the age in weeks. Answer as accurately as possible for aluminothermic welds. Detailed weld information may not be readily available for welds older than 1-2 years. This information should, however, be readily available for new welds as it is written on the weld or available from area databases. If a flash butt weld the age will be the same as the rail age for all practical purposes.

Weld Number	If the defect or break is at a weld, what is the weld number? Read the number from the Weld Identification sticker adjacent to the weld. Older welds may not have this label.
Welder's licence No. ***Area office to complete***	If the defect or break is at a weld, what is the licence number of the welder who installed the weld? Write down the number.
Probable failure type	*For Broken Rails only* - Complete fields relating to the break as far as possible. Put a 8 in the appropriate box. Information contained in Engineering Manual TMC 226 Rail Defects Handbook can assist in making assessments.
Direction	
Defect type	*For Rail Defects only* - Complete fields relating to the break as far as possible. Put a 8 in the appropriate box. Information contained in Engineering Manual TMC 226 Rail Defects Handbook can assist in making assessments.
Defect size	For Rail Defects only. What size is the defect?. Put a 8 in the appropriate box.
Rail	
Rail Section	Rail weight in kilograms per metre. Is it Head hardened or standard carbon? This information is stamped on the rail. Circle the answer or write the weight if "other".
Date of rolling	This Information is found on the web of the rail. Give true dates in months and years, e.g., for July 1985 write 0785. If not available estimate as accurately as possible.
Manufacturer	Information is found on the rail web. Circle the answer or write the weight if "other".
Position in ingot and Heat Number	Record the number (usually a letter (A to I) followed by 8 numbers.
Track Information	
Radius ***Area office to complete***	Find the radius from a curve and gradient book or G Sheets. Circle Straight or write in radius in metres.
Length of rail between joints	Is it CWR or jointed? If it is jointed, how long is rail length in which the defect or broken rail occurred. Circle CWR or write the length in metres.
Sleeper type	Put a 8 in the appropriate box.
Sleeper condition	Put a 8 in the appropriate box or write in a response.
Track condition	Write description eg good, fair, poor.
Fastenings	Put a 8 in the appropriate box.
Rail adjustment	Put a 8 in the appropriate box.
Rail Temperature	*For Broken rails only*. What was the rail temperature at the time of the break? Estimate if not known. Write down the answer.
Width of Gap	*For Broken rails only.* What was the size of the gap between the two broken rail ends? Write down the answer
Last RFD Car run ***Area office to complete***	When was the rail last tested by the Rail Flaw Detection Car. Enter the date in the boxes.
KK Test date ***Area office to complete***	If the defect or break is in a weld or in a turnout, when was the last test by a KK operator? Enter the date in the boxes.

Was the defect ***Area office to complete***	Circle YES or NO. It is important to note if the rail was unable to be tested on the last run and the reason for this.
Remedial Action	
Action taken ***Area office to complete***	For Broken Rails ONLY. What remedial action was taken until permanent repairs could done? Write down the answer.
Speed restriction ***Area office to complete***	What speed restriction was applied until permanent repairs could be done? Write down the answer.
Team Manager to complete	
Plate by	This item is provided to detail the remedial measures to be taken and who is to deal with it.
Remove by	This item is provided to detail the remedial measures to be taken and who is to deal with it.
Employee removing defect to complete	
Date plated/removed	Fill in after plating or replacing the defective rail and return copy to Team Manager.
Team Manager to complete	
Team Manager signed	Sign and date the form. Make sure as much information as possible has been included.

Chapter 14 A guide to completing a Weld Alignment Failure form

Complete a Weld Alignment Failure Form WAF1 (See Appendix 2) when an aluminothermic or wirefeed weld does not pass the geometry alignment test. Most of the information can only be obtained on-site.

Person finding a weld alignment failure	
Date of failure	There are six "boxes" in this section for recording data. The date of the failure is recorded in these boxes. For example, if the rail failed on 28 February 2005, the completed boxes would appear as: 2 8 0 2 0 5
Location	
District	What District was it found on? Put a 8 in the appropriate box.
Kilometres	The location of the defect, recorded as kilometres to the nearest metre. eg 27.359
Base Code / Track	RailCorp has been divided up into small sections and each different section is given a different code number. Write down the line eg Bankstown, Illa Local, Suburban, Main North.
	The track on which the rail failed. Circle the answer.
	Type of track. Main, Suburban, Refuge etc. Circle the answer
Rail	The rail on which the failure occurred. Circle the answer. UT = Up Turnout Rail, DT = Down Turnout Rail
Weld Number	Read the number from the Weld Identification sticker adjacent to the weld.
Welder's licence No. ***Area office to complete***	*Area office to complete* If the defect or break is at a weld, what is the licence number of the welder who installed the weld? Write down the number.
Detection	
Method of finding defect	Circle the answer or write a response.
Defect	
Tested to	What Acceptance limits did you apply? Put a 8 in the appropriate box.
Defect type	Complete fields relating to defect type. Put a 8 in the appropriate boxes.
Defect size	What size is the defect?. Write the size in mm to 2 decimal places.
	Is it a Small (S) Medium (M) or Large (L) defect. Check Section C4-3 for definition of sizes. Put a 8 in the appropriate boxes.
Suggested method of removal	Circle the answer or write a response.
Track Information	
Radius ***Area office to complete***	Find the radius from a curve and gradient book or G Sheets. Circle Straight or write in radius in metres.

Rail Section ***Area office to complete***	Rail weight in kilograms per metre. Is it Head hardened or standard carbon. This information is stamped on the rail. Circle the answer or write the weight if "other".
Sleeper type ***Area office to complete***	Put a 8 in the appropriate box.
Sleeper condition ***Area office to complete***	Put a 8 in the appropriate box or write in a response.
Fastenings ***Area office to complete***	Put a 8 in the appropriate box
Age of Weld ***Area office to complete***	If the defect or break is at a weld, how old is it? Enter the answer in the boxes. For welds less than 1 year old enter the age in weeks. Answer as accurately as possible for aluminothermic welds. Detailed weld information may not be readily available for welds older than 1-2 years. This information should, however, be readily available for new welds as it is written on the weld or available from area databases. If a flash butt weld the age will be the same as the rail age for all practical purposes.
Last Tolerance test ***Area office to complete***	When was the weld last tested for alignment defects? Enter the date in the boxes.
Remedial Action	
Team Manager to complete	
Instructed to	This item is provided to detail the remedial measures to be taken and who is to deal with it.
Employee removing defect to complete	
Date removed	Fill in after replacing the defective rail and return copy to Team Manager.
Team Manager to complete	
Team Manager signed	Sign and date the form. Make sure as much information as possible has been included.
Rail flaw detection operator to complete (if defect removed by grinding)	
Date retested	Enter retest date and sign.
Tested	Put a ✓ in the appropriate box. If failed, complete a new Weld Alignment Failure Form and enter the Form No. in the box.

Chapter 15 Variation of testing intervals

Rails are tested for internal defects by the rail flaw detection vehicle at locations and frequencies established in ESC 100 Technical Maintenance Plan.

The basis for determining testing intervals is primarily tonnage at intervals of 3 to 6 million gross tonnes.

This tonnage generally reflects the growth rate of rail discontinuities, however, existing testing intervals have been established on the basis of the additional factors detailed below.

Testing intervals on main lines may be shortened with the approval of the Civil Maintenance Engineer after consultation with the Chief Engineer Track.

Testing intervals may be lengthened only with the approval of and Chief Engineer Track for main lines, and of the Civil Maintenance Engineer for other lines, after taking into account all relevant factors.

The factors that are to be considered are:

- rail weight,
- rail quality,
- rail age and condition,
- annual tonnage,
- current and proposed axle loads,
- residual stress in the rail head,
- thermal stress,
- seasonal variations,
- rail grinding program,
- sections with sharper radius curves,
- propagation rate of rail defects,
- rail defect rate per kilometre,
- incidence of broken rails,
- type of traffic including extent of passenger traffic,
- economic analysis of system costs of a broken rail and costs of rail testing,
- testing intervals in adjacent sections,
- availability and cost of examination resources,
- line type (main line, siding, loop etc).

When minimum testing intervals are proposed to be varied, the proposing officer must document the basis for the change. The recommended maximum variation is:

- In the case of a shorter interval, the new testing interval shall not be shorter than half of the previous interval.
- In the case of a longer interval, the new testing interval shall not be longer than twice the previous interval.

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Chapter 16 Rail Defect Removal Risk Assessment

The potential for a rail defect to grow in size and lead to a broken rail is considered in the responses defined in Chapter 4.

If it not possible to remove a rail defect within the time limits detailed in Section C4-6, the Civil Maintenance Engineer shall undertake a risk assessment to establish appropriate management of the risk.

C16-1 Risk assessment methodology

Review the defect

1. How severe is the defect? Is it small or large?
2. How long before you are able to have it removed?
3. Can trains operate safely over the defect? Can you impose a speed restriction?
4. How heavy is the traffic? - Number of trains, axle loads etc.
5. What are the consequences of a broken rail at this site?
   - ~ Will the rail break clean, or will it break in multiple pieces?
   - ~ Will the break be straight or will it more likely create a foul joint?
6. Do you need to increase the surveillance of the defect? This may include additional ultrasonic testing or increased visual monitoring.

C16-2 Minimum requirements

The minimum requirement is for the defect to be re-tested at a frequency equivalent to the repair requirement detailed in Section C4-6 (e.g. if mandatory response is "remove within 7 days", then the defect must be re-tested within 7 days).

At locations where only 2 bolts (one each side of the defect) have been used to secure the plates, no extension is permitted unless 4 bolts have been installed.

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Chapter 17 Ultrasonic Bolt Testing

C17-1 Introduction

Broken rail brace bolts may cause signal failures. This problem is mainly related to non-approved rail brace bolts which have been installed in the past. The bolts typically break at the top of the shank. Ultrasonic bolt testing, using an ultrasonic crack measuring instrument, can detect cracks and potential failures in bolts.

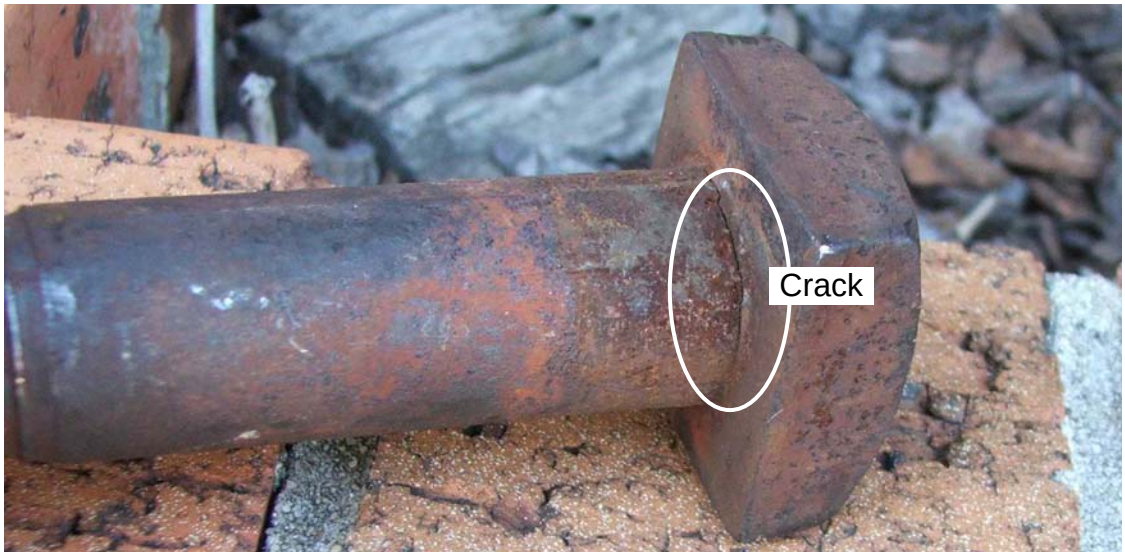

Figure 34 – Location of cracking

C17-2 Test locations

Carry out testing at:

- High risk locations, such as those where non-approved bolts have been identified

  Non-approved bolts can be identified from the markings on the head (see Chapter C5-5 of TMC 251 – Turnout Installation and Repair Manual). Bolt inspections may be used as an alternative to replacement of non-approved bolts.
- High risk locations where there is a history of failures.
- Locations where upgrading or major maintenance work is planned in turnouts.

  Take the opportunity to replace any incorrect bolts with the correct type, along with any worn or distorted bolts noted in service.

C17-3 Instrument

The recommended instrument is a Krautkramer DM4E ultrasonic thickness gauge, with a DA 301 probe. A smaller probe (TM2 002) is also available for testing in difficult access locations, ie where holding down bolts etc obstruct the larger probe.

C17-4 Calibration

Check the calibration of the probe before each use, or once per day, whichever is the longer period.

Extreme accuracy is not necessary for bolt testing or squat depth determination. Use the probe to measure the thickness of a test block of known thickness (checked with vernier). If the distance measured by the probe matches the depth of the test block within 1% (0.2 mm for bolt testing or 0.05mm for squat depth identification the calibration is satisfactory. If greater accuracy is required for other uses follow the calibration requirements in the manufacturer's user manual.

The test block should be of the same material as the material that will be gauged. Calibration should be carried out at the same temperature as testing.

C17-5 Testing Method

1. Identify bolts for testing. Normally this would include all rail brace bolts in the switch area with potential to jam the switch (see Figure 35).
2. Determine the overall length of the bolt by measuring bolt projection from the web of the rail, and adding amounts for the web thickness (usually 15mm) and the bolt head depth (also usually 15mm). Rail brace bolts in the switch area are typically 135mm to 140mm long. If washers or studs are present they should also be allowed for.

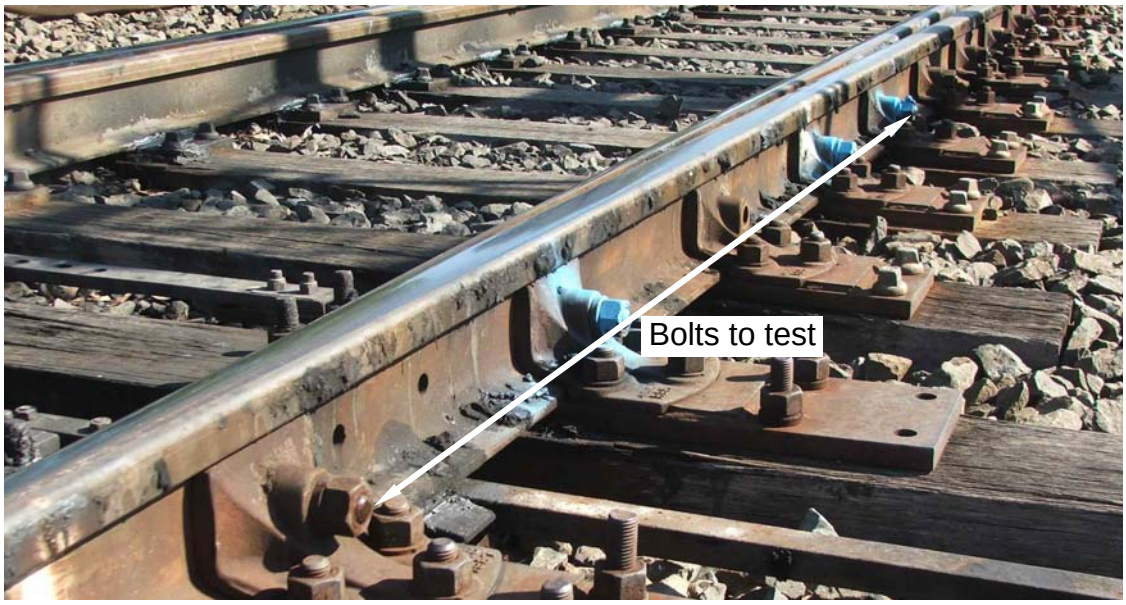

Figure 35 – Bolts to be tested

3. Place the measuring probe at the end of the bolt, using ample coupling medium, and aim the probe straight down the bolt. Instrument screen readings should give the distance in mm to the nearest reflection of the ultrasonic signal. For a sound bolt this will be either the overall length of the bolt (usually 135mm to 140mm) or reflections from the bolt threads (up to about 80mm).

Figure 36 – Testing the bolt from the nut end

4. Move the probe around to pick up as many reflections as possible, indicating distances to the end of the bolt as well as bolt threads.

   Any steady readings found which represent the bolt length minus the head depth (ie 125mm

for a 140mm bolt with a 15mm head depth) indicate a crack at the top of the shank.

This method should reliably find any cracks deeper than 6mm. Indications of smaller cracks may be found less consistently.

Extra coupling medium will help to obtain a reading on rough bolt ends.

The smaller probe is generally more sensitive to irrelevant reflections such as bolt threads, and should only be used where the larger probe does not fit.

5. Remove defective bolts as soon as possible.

Chapter 18 Inspection of Monobloc Crossings

C18-1 Introduction

Inspect monobloc crossings using the following procedures.

The crossings are the same material as the manganese crossing noses already in widespread use. With monobloc the whole crossing is made from manganese including the wing section and all joining material. The monobloc section is flashbutt welded to 60kg/m rail so the crossing can be welded into track in the same way as current crossings (see Figure 37).

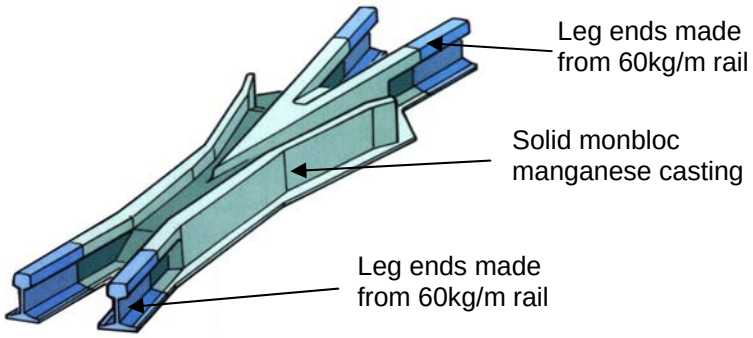

Figure 37 – Monobloc Illustration

The monobloc crossing has features that are different to conventional crossing designs. Like other manganese components they cannot be ultrasonically tested.

C18-2 Inspection requirements

As with other crossings that cannot be ultrasonically tested monobloc crossings must be visually inspected. Dye penetrant inspection can be used to provide additional information on the extent of cracks.

1. Clean the crossing surfaces where necessary with a wire brush so they can be visually inspected.
2. Use a hand mirror to inspect the underside parts where direct vision is limited e.g. underside of the rail head.
3. Inspect the whole visible surface area of the monobloc crossing including the rail ends at either end of the crossing. This includes areas not normally inspected such as the bottom of the flangeway and the aprons at either end. Areas of particular interest also include longitudinal changes of section, the foot area and around the flashbutt welds joining the monobloc to conventional rail (see Figure 38).
4. If a crack is seen as coming from behind a plate (that can be removed) be remove it to assess the extent of the crack. If there are no visible cracks it is not necessary to remove plates.

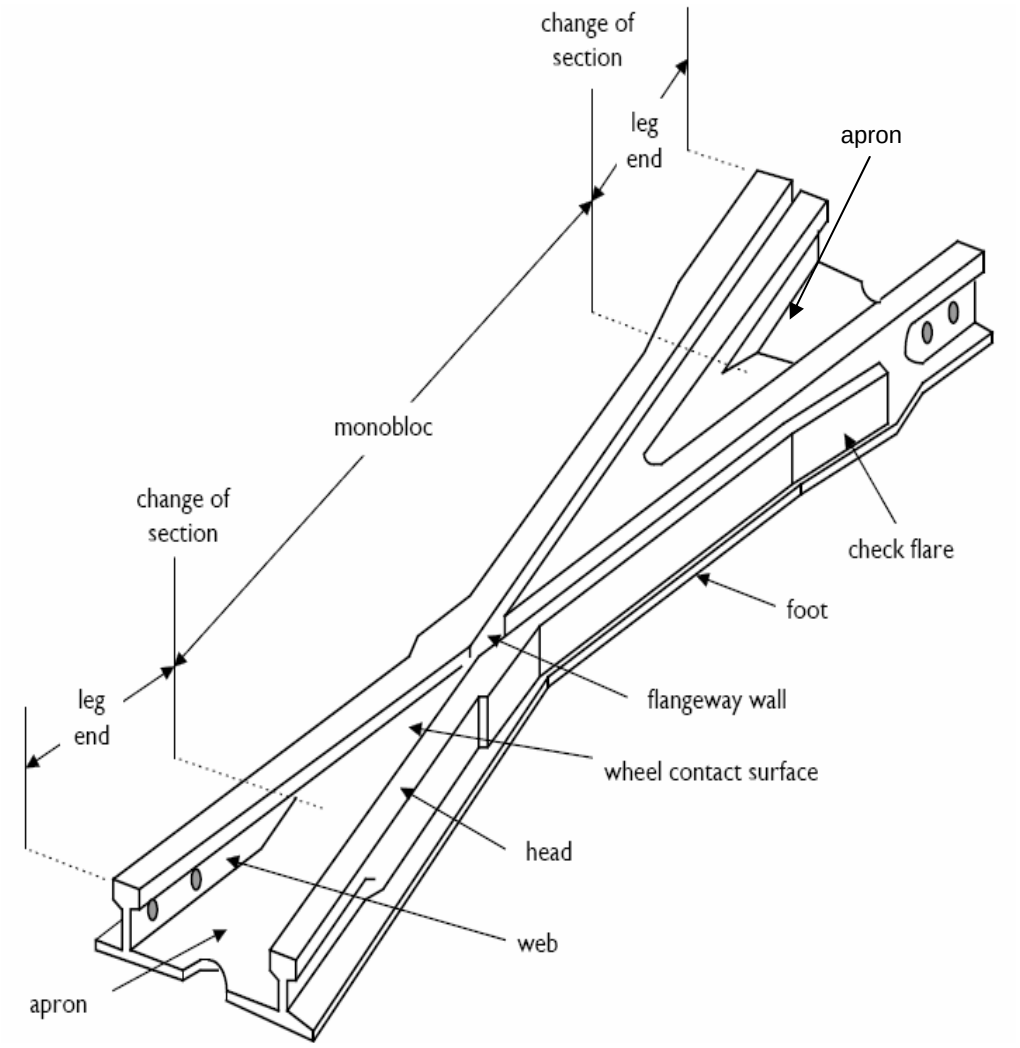

Figure 38 – Parts of a monobloc crossing

C18-3 Defect classifications

Use current rail defect classifications for rail and crossing defects as detailed in Table 6 in Section C4-6.

For all defects except transverse defects the visible crack length can be treated as probe movement for sizing categories. For transverse defects the crack lengths should be used instead of probe movement (see Table 13). Defects should be considered as if they are plated where substantial additional support is provided by the adjoining material in the flangeway or table area.

Internal Rail Defects - Limits and Responses							
	Defect Type	**Crack Length (mm) (See Notes)**		**TSR (km/h)**	**Plate Within (See Notes)**	**Remove Within**	**Other Action**
1	**Transverse Defect (TD)** Head - 70^0 Probe	S	12 to 18		7 days	5 months	
		M	19 to 28		24 hours	5 weeks	
		L	29 to 40	30	2 hours	48 hours	Inspect clamp/ bolts after 24hrs of installation
		E	≥40	20		ASP	Monitor defect (min 6hrly) and stop trains if necessa until defect removed

Table 13 - Crack lengths for transverse defects in monobloc crossings

There are two areas of monobloc crossings not described in Table 6 of Section C4-6.

- the bottom of the flangeway and
- the aprons at either end of the crossing.

If cracks are found in these areas size them the same as cracks in the web of the rail considering:

- If crack is parallel to the rail – treat as horizontal split web (HSW)
- If crack is perpendicular to the rail – treat as transverse vertical web defect

C18-4 Surface irregularities

Defect classifications refer to cracks which have grown in service. If surface irregularities from casting defects are visible treat them as follows:

- If these defects DO NOT show growth
  - paint mark them, and
  - report them to the Team Manager for monitoring during routine patrols.
- If they DO show signs of crack growth
  - reclassify the defect in accordance with the Table 13 considering the full length of the defect.

If any defects have been classified as medium or greater, recheck them at not greater than four weekly intervals.

Report all defects requiring action to be taken, including any significant casting defects, to the Chief Engineer Track and to Rail Inspection Services.

Appendix 1 Rail Fail Form

Defect No. ____

Rail Fail Form

Form RF1

DATE OF FAILURE ____ ____ ____ ____ ____ ____ RAIL DEFECT ☐ **BROKEN RAIL** ☐

LOCATION

DISTRICT: Central ☐ Illawarra ☐ West ☐ North ☐ Infrastructure Facilities ☐ **KILOMETRES** ____

BASE CODE /TRACK: BASE CODE ____ LINE ____ TRACK: UP ☐ DN ☐ SINGLE ☐

Main ☐ Suburban ☐ Local ☐
Relief ☐ Through ☐ Refuge ☐
Loop ☐ Platform Rd ☐ Siding ☐

RAIL: UP ☐ DN ☐ UT ☐ DT ☐ CP ☐ | High Rail ☐ Low Rail ☐ Tangent ☐

DETECTION

METHOD OF FINDING DEFECT: Signal Failure ☐ Visual ☐ Rail Flaw Detection Car ☐ Manual Ultrasonic Test ☐ Special Manual Ultrasonic Test ☐ Rail Cleanliness Testing ☐
Derailment/Mishap ☐ Train crew ☐ Other ☐ …… Name of KK Operator ……

For Broken Rails: WHEN FOUND ____ **hrs** REPORTED TO …… WHEN REPORTED ____

DEFECT OR BREAK

POSITION: At Weld ☐ At joint (within fishplates) ☐ At GIJ (within fishplates) ☐
In Plain Rail ☐ ……m from Aluminothermic weld ☐ Flashbutt weld ☐ Rail end ☐
In Switch ☐ In Stockrail ☐ In Crossing ☐ In Wing rail ☐

If defect at weld: WELD TYPE Flashbutt ☐ Aluminothermic ☐ Wirefeed ☐ **AGE OF WELD IN YEARS** ____ **OR WEEKS** ____
WELD NUMBER ____ WELDER'S LICENCE NO ____

For Broken Rails ONLY

PROBABLE FAILURE TYPE: TD Shelling ☐ Squat ☐ Shatter crack ☐ TD Wheelburn ☐ Gassing ☐ Hot tear ☐ Wirefeed Weld ☐
Impact Damage ☐ Corrosion ☐ Bolthole ☐ Clean Break ☐ Other …… No Obvious Defect ☐

DIRECTION: Transverse vertical ☐ Diagonal ☐ Horizontal ☐ Star ☐

For Rail Defects ONLY

DEFECT TYPE: TD ☐ TDX ☐ SC ☐ TD/EBF ☐ DWFW ☐ DW ☐ DWC ☐ DWF ☐ VSH ☐ VSW ☐ TSW ☐ BH ☐
PR ☐ HSW ☐ HSH ☐ HWS ☐ FWS ☐ CR ☐ MJS ☐ Weld Geometry ☐ Proximity to holes, welds etc ☐
Foot Damage ☐ Other …… **DEFECT SIZE** S ☐ M ☐ L ☐ E ☐

RAIL

RAIL SECTION: 60HH ☐ 60 ☐ 53 ☐ 47 ☐ Other _____ DATE OF ROLLING ____ M ____ Y
MANUFACTURER: AIS ☐ BHP ☐ OneSteel ☐ Other ____ **POSITION IN INGOT AND HEAT No.** ____

TRACK INFORMATION

RADIUS: Straight ☐ Curved ☐ ……m LENGTH OF RAIL (between joints): CWR or ……m
SLEEPER TYPE: Timber ☐ Concrete ☐ Sleeper on Concrete ☐ Slab track etc ☐ Mixed timber and concrete ☐ SLEEPER CONDITION: Good for 5 years or more ☐ Split ☐ Broken or rotten ☐ Other ☐ ……
TRACK CONDITION …… FASTENINGS: Dogspikes and lockspikes ☐ Dogscrews and lockscrews ☐ Pandrol clips ☐ Fastclip ☐ Other resilient fastenings ☐
RAIL ADJUSTMENT: Adjustment correct ☐ Short of steel ☐ Excess of steel ☐
For Broken Rails ONLY: **RAIL TEMPERATURE** ____ ^{0}C **WIDTH OF GAP** ____ mm
LAST R.F.D CAR RUN: ____ D ____ M ____ Y
IF WELD OR T/O KK TEST DATE: ____ D ____ M ____ Y
WAS DEFECT DETECTED YES ☐ NO ☐

REMEDIAL ACTION

ACTION TAKEN …… **SPEED RESTRICTION** ……

PLATE by **……. / ……./ ……..**
Signed ……..Team Manager Date: **…. / ……./……..**

REMOVE by **……. / ……./ ……..** **using closure / rail length**
Signed ……..Team Manager Date: **…. / ……./……..**

DATE PLATED …. / …./ ….. **Signed:**……

DATE REMOVED …. / …./ ….. **Signed:**……

TEAM MANAGER Signed:…… Date: …. / …./…..

TEAM MANAGER Signed:…… Date: …. / …./…..

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Appendix 2 Weld Alignment Failure Form

Defect No. ☐☐☐☐☐☐

Weld Alignment Failure Form

Form WAF1

DATE OF FAILURE ☐☐ ☐☐ ☐☐

LOCATION

DISTRICT: Central ☐ | Illawarra ☐ | West ☐ | North ☐ | Infrastructure Facilities ☐ | **KILOMETRES** ☐☐☐•☐☐☐

BASE CODE /TRACK: ☐☐ BASE CODE | ☐☐☐ BASE CODE | ☐☐☐ LINE | ☐☐☐ LINE | UP ☐ DN ☐ SINGLE TRACK ☐ | Main ☐ Suburban ☐ Local ☐ Relief ☐ Through ☐ Refuge ☐ Loop ☐ Platform Rd ☐ Siding ☐ | RAIL: UP ☐ DN ☐ UT ☐ DT ☐ CP ☐ | High Rail ☐ Low Rail ☐ Tangent ☐

WELD NUMBER ☐☐☐☐☐☐ | WELDER'S LICENCE NO ☐☐☐☐☐☐☐☐

DETECTION

METHOD OF FINDING DEFECT: Visual ☐ Weld Acceptance test ☐ Derailment/Mishap ☐ Other ☐ ……

DEFECT

TESTED TO: New Track Acceptance Limits ☐ Existing Track Acceptance Limits ☐

DEFECT TYPE	Vertical			Horizontal		
	Peak ☐	Dip ☐	Step ☐	Gauge Narrow ☐	Gauge Wide ☐	Step ☐

DEFECT SIZE ☐•☐☐ mm S ☐ M ☐ L ☐

SUGGESTED METHOD OF REMOVAL: CLOSURE | GRINDING

TRACK INFORMATION *TO BE COMPLETED BY TEAM MANAGER*

RADIUS: Straight or ……m | RAIL SECTION: 60HH | 60 | 53 | 47 | Other ___

SLEEPER TYPE: Timber ☐ Concrete ☐ Sleeper on Concrete ☐ Slab track etc ☐ Mixed timber and concrete ☐ | FASTENINGS: Dogspikes / lockspikes ☐ Dogscrews / lockscrews ☐ Pandrol clips ☐ Fastclip ☐ Other resilient fastenings ☐

AGE OF WELD IN YEARS ☐☐ | **LAST TOLERANCE TEST** Never ☐ < 1 Month ☐ 1 – 6 Months ☐ 7 – 12 Months ☐

REMEDIAL ACTION

…… (Name) instructed to remove Weld exceedent **by ……. / ……./ ……..**

using CLOSURE/GRINDING (delete whichever is not applicable)

Signed …….. Team Manager ……. / ……./ …….. Date

TO BE COMPLETED BY PERSON REMOVING DEFECT

Date removed from track ……/……./……. | **Signed:** ……

TO BE COMPLETED BY TEAM MANAGER

Team Manager | Signed …… | Date ……/……./…….

TO BE COMPLETED BY RAIL FLAW DETECTION OPERATOR (if defect removed by grinding)

Date retested ……/……./……. | **Signed:** ……

Tested OK ☐ FAILED ☐ | If failed, complete a new Weld Alignment Failure Form | Form No. ☐☐☐☐☐☐

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Appendix 3 Welding Return

Weld Return

Form WR1

Welder's Details

Welder's Name | Licence No. | Signature

Weld Details

Weld Date (D M Y) | Base Code /Track (BASE CODE / LINE) | UP DN (TRACK)

District | Km • | Rail: UP DN UT DT

Weld Number | Rail Size: 60HH 60 53 47 Other ___ | Weld Reason | Weld Type

Weld Condition | Weather Condition | Track Condition | Batch Number

Punch Mark Before ____ mm | Punch Mark After ____ mm | Adjustment Maintained: YES NO

Rail Temperature ____ ^{0}C | Has weld been packed? YES NO | Are closures less than 6m in length crowed to correct curvature? YES NO

Comments

Weld Testing Data

Test Date (D M Y) | Ultrasonic Pass: YES NO | Alignment Pass: YES NO | Punch Mark Check ____ mm

Rail Fail ID | Alignment Failure ID

RFD Operator's Name | Signature

Retest (Alignment

Test Date (D M Y) | Alignment Pass: YES NO | Alignment Failure ID

RFD Operator's Name | Signature

Comments

Weld Details

Weld Date (D M Y) | Base Code /Track (BASE CODE / LINE) | UP DN (TRACK)

District | Km • | Rail: UP DN UT DT

Weld Number | Rail Size: 60HH 60 53 47 Other ___ | Weld Reason | Weld Type

Weld Condition | Weather Condition | Track Condition | Batch Number

Punch Mark Before ____ mm | Punch Mark After ____ mm | Adjustment Maintained: YES NO

Rail Temperature ____ ^{0}C | Has weld been packed? YES NO | Are closures less than 6m in length crowed to correct curvature? YES NO

Comments

Weld Testing Data

Test Date (D M Y) | Ultrasonic Pass: YES NO | Alignment Pass: YES NO | Punch Mark Check ____ mm

Rail Fail ID | Alignment Failure ID

RFD Operator's Name | Signature

Retest (Alignment

Test Date (D M Y) | Alignment Pass: YES NO | Alignment Failure ID

RFD Operator's Name | Signature

Comments

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Welding Return

Form WR2

Welder's Name		*Welder's Signature*		*Date*	
Licence No.		*Welder's Home Station*			
Week Ending		*Supervisor's Signature*		*Date*	

Ultrasonic Operator	
Name	
Signature	

WELDER TO COMPLETE

RAIL FLAW DETECTION OFFICER TO COMPLETE

Weld Location					Weld Detail													Ultrasonic and Alignment Test						
											Site Conditions /Codes			Steel in-Steel out									Alignment Retest	
Line No.	Date	Sector Code	Track	Km	Rail (U/D)	Rail Size	Weld Reason (Code)	Batch No.	Weld Sticker No.	Weld Type (Code)	Weld	Weather	Track	Punch Marks Before	Punch Marks After	Rail Temp ^{0}C	Tensors YES or NO	Date	**OK** YES or NO	Rail Fail No. OR Alignment Failure No.	Defect Type Rail or Alignment	**Punch Mark Check**	**Date**	**Alignment Pass YES or NO**
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								

NOTES

Associated Work	
Have welds been packed?	YES NO
Are closures less than 6m in length crowed to correct curvature?	YES NO
Do rail ends and closures match existing rail?	YES NO

Appendix 4 Wire Feed Welding Return

Wire Feed Weld Return

Form WFR1

Welder's Details

Welder's Name | Licence No. | Signature

Weld Details

Weld Date (D M Y) | Base Code /Track (BASE CODE / LINE) | TRACK (UP DN)

District | Km | Rail (UP DN UT DT)

Weld Number | Weld Type (WHEELBURN / CROSSING REPAIR) | Wire Type

For plain track ONLY

Rail size (60HH 60 53 47) | Defect Depth ___ mm | Defect Length ___ mm

For Crossing Repairs ONLY

Nose Repair Depth ___ mm | Nose Repair Length ___ mm | Yard (YES NO)

Main Wing Repair Depth ___ mm | Main Wing Repair Length ___ mm | Turnout Number/type

Turnout Wing Repair Depth ___ mm | Turnout Wing Repair Length ___ mm

Comments

Weld Testing Data

Test Date (D M Y) | Ultrasonic Pass (YES NO) | Defect Size (S M L) | Alignment Pass (YES NO)

Defect Location | Rail Fail ID | Alignment Failure ID

RFD Operator's Name | Signature

Retest (Alignment only)

Test Date (D M Y) | Alignment Pass (YES NO) | Alignment Failure ID

RFD Operator's Name | Signature

Comments

Weld Details

Weld Date (D M Y) | Base Code /Track (BASE CODE / LINE) | TRACK (UP DN)

District | Km | Rail (UP DN UT DT)

Weld Number | Weld Type (WHEELBURN / CROSSING REPAIR) | Wire Type

For plain track ONLY

Rail size (60HH 60 53 47) | Defect Depth ___ mm | Defect Length ___ mm

For Crossing Repairs ONLY

Nose Repair Depth ___ mm | Nose Repair Length ___ mm | Yard (YES NO)

Main Wing Repair Depth ___ mm | Main Wing Repair Length ___ mm | Turnout Number/type

Turnout Wing Repair Depth ___ mm | Turnout Wing Repair Length ___ mm

Comments

Weld Testing Data

Test Date (D M Y) | Ultrasonic Pass (YES NO) | Defect Size (S M L) | Alignment Pass (YES NO)

Defect Location | Rail Fail ID | Alignment Failure ID

RFD Operator's Name | Signature

Retest (Alignment only)

Test Date (D M Y) | Alignment Pass (YES NO) | Alignment Failure ID

RFD Operator's Name | Signature

Comments

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Appendix 5 Turnout and Weld Testing Report

Monthly Turnout and Weld Testing Report

Form MRTR1

Month.	Year	Area	Name/s of operator/s

- *Indicate all defects located in turnouts by ticking or writing in appropriate squares.*
- *In column marked 'Defect in'* **C** *= Crossing- write* **N** *for nose or* **WR** *for wing rail*
- *In column marked 'Defect in'* **S** *= Switch- write* **B** *for blade or* **HB** *for Heel Block,*
- *Tick* **ST** *= Stock Rail,* **R** *= rail or* **CP** *= Catchpoint*
- *In columns marked 'Type and Size' indicate defect size* **S, M, L or E** *in the appropriate square*

COMPLETE THE FORM AT THE END OF EVERY MONTH AND SEND TO:
Rail Inspection Services
Fax 25873 or Email

Nearest Station location	Turnout No.	Track	Rail	Rail weight	Year rolled	Defect in							Type & size of defects												
						C		S		ST	R	CP	VSH	TD	EBF	SC	HSH	HW	HSW	PR/ VSW	BH	DW	DWR W	BR	C Pr
						N	W	B	HB																

Total turnouts tested

Mainline Turnouts		Catchpoints			**Secondary line** Turnouts		Catchpoints	
Total defects **Mainline**					Total defects **Secondary line**			

Aluminothermic Weld testing	
Total No. of Welds tested	
Total No. of Welds defective	
Total No. of HEAD defects	
Total No. of WEB defects	
Total No. of FOOT defects	
Total No. of welds not within alignment tolerance	

Wirefeed Weld testing	
Crossing repairs	
Total No. of weld repairs tested	
Total No. of weld repairs defective	
Total No. of Repairs not within alignment tolerance	
Rail repairs	
Total No. of weld repairs tested	
Total No. of weld repairs defective	
Total No. of Repairs not within alignment tolerance	

Operator's signature	……..	Date _____20